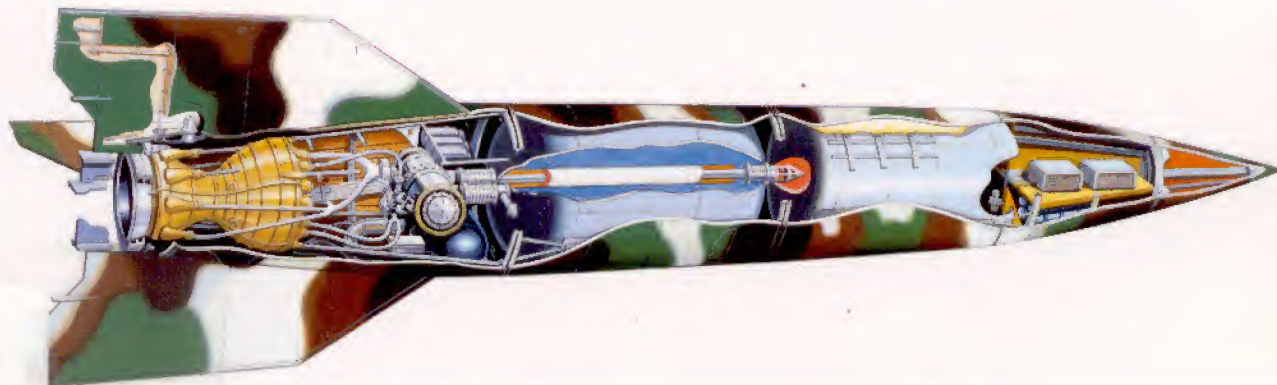


V-2 Ballistic Missile 1942–52



Steven J Zaloga • Illustrated by Robert Calow



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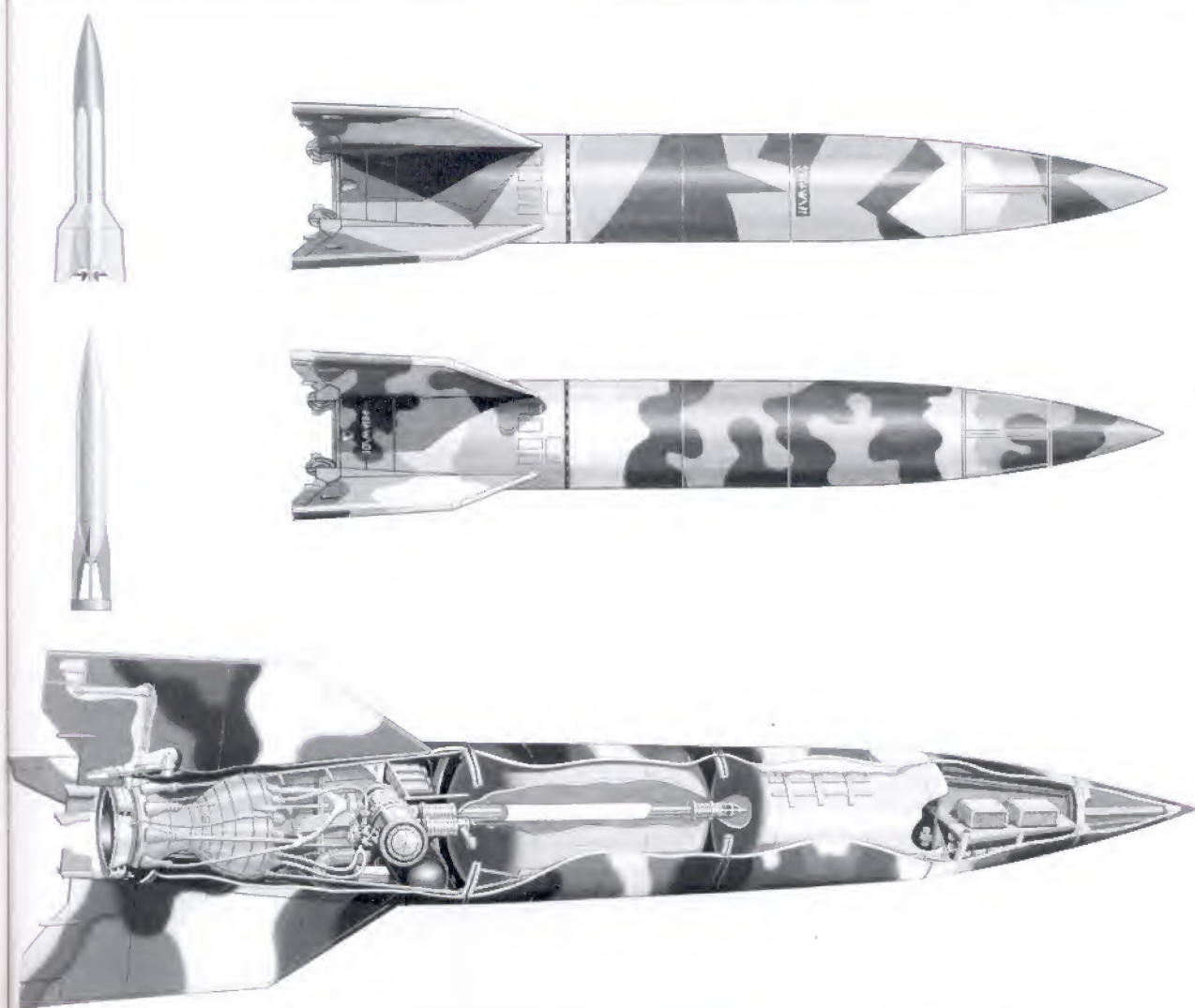


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V-2 BALLISTIC MISSILE 1942-52

INTRODUCTION

The German V-2 was the world's first ballistic missile used in combat. It was a technological marvel that pioneered many key innovations in missile technology. But as a weapon, it was a complete flop, costing Germany enormous resources for very meager results. After World War II the V-2 and its engineers played a vital role in post-war space programs in both the United States and the Soviet Union. While much has been written about the development of the V-2 missile, the focus of this book is on its combat use during 1944-45.

EARLY GERMAN ROCKET DEVELOPMENT

In the 1920s and 1930s, there was a flurry of interest among young aeronautical enthusiasts in the development of liquid-fueled rockets.

Inspired by fictional accounts of future space travel, these pioneers laid the ground work for missile development in World War II. Compared to the other major powers, Germany raced ahead in the military applications of rocket technology due to the decisions of the German Army in the 1930s to support the rocket enthusiasts financially and to provide them with facilities and personnel for their work.

The most significant proponent of rocket weapons in the pre-war Reichswehr was Oberstleutnant Karl Becker, the head of the ballistics and munitions section of the Army ordnance branch. Becker had been involved in the development of the Paris Gun in World War I and saw rockets as a more advanced form of long-range artillery. On Becker's staff was a young artillery officer, Hauptmann Walter Dornberger, who would later lead the V-2 program. After experiments with solid fuel rockets in 1929-30, Becker became interested in pursuing the development of liquid-fuel rockets since they offered the potential of much greater range and payloads. The problem with early solid fuel rockets was that only about a quarter by weight of their propellant was the active fuel ingredient, while the remaining three-quarters

An A-4 missile on its launch stand during the missile campaign of 1945. Due to the secrecy attached to the program, few photos of the actual combat launches were taken, and this one was part of a small collection captured by the US Army in 1945. (MHI)



was the inert binder needed to form the engine. Such rocket engines were extremely inefficient in terms of the amount of thrust for the weight of the engine. By contrast, liquid fuel engines offered considerably more thrust for their weight, even counting the added weight of their fuel tanks and combustion chamber. The combination of liquid oxygen and alcohol was favored by early rocket pioneers as it had the highest specific impulse, that is the greatest fuel efficiency, of any fuel combination then available. Becker convinced Werner Freiherr von Braun, a talented young member of a Berlin amateur rocket group, to assist in the development of liquid fueled rockets. Von Braun was a doctoral candidate in physics at the University of Berlin and was given facilities at the artillery proving ground at Kummersdorf to carry out rocket experiments.

The German missile program was small until the Nazi rise to power. There was considerable enthusiasm for such futuristic weapons among the Nazi leaders and, with military funding available, the missile program expanded considerably. The program was to be conducted in complete secrecy, so a test site away from Berlin was desired. Von Braun suggested the Baltic coast and the secret weapons center was established at Peenemünde on Usedom in May 1937. In the mid-1930s the leadership of the German Army was dominated by artillery officers since the artillery branch had been so vital in World War I. Their enthusiastic support was the driving force behind the program.

The first rocket of the program, the A-1 (*Aggregat 1*; Assembly 1) weighed a mere 135kg (298lb) and had an engine with a thrust of 300kg (661lb). Von Braun recalled: "It took us half a year to build and exactly one-half second to blow up." The A-2 was a redesigned version of the A-1 and two were flown in 1934 to a height of 2.4km (1½ miles). The next rocket was the A-3, with a thrust of 1,500kg (3,308lb). The first two launches failed due to guidance problems and the next two, while more successful, suggested significant control problems. In spite of these meager accomplishments, in 1936 the Army approved the development of the A-4 missile, the first actually intended as a weapon. It would later be known by its propaganda name of V-2. To help sell it to the Army, Dornberger proposed a one-ton payload and a range of 270km (168 miles), twice the range and 100 times the payload of the Paris Gun of World War I. The objective was to field the new weapon by 1943.

With the A-4 designation already reserved, the next test-bed missile was designated A-5. It was the first of the Peenemünde rockets to resemble the eventual A-4 design, except that it was only about one half the size. Launches began in October 1938 and over two dozen A-5 rockets were launched to the end of 1941 to perfect the advanced inertial guidance system.



An A-4 takes off in a plume of dust from Test Stand VII at Peenemünde in the spring of 1943. The characteristic black and white segmented paint finish is obscured by a band of ice which has condensed around the liquid oxygen tank above the fins. (NARA)



The two key figures in the development of the A-4 were General Walter Dornberger, seen here to the left with the cigar, and Werner von Braun, with the cast on his arm. This photo was taken in May 1945 after they had surrendered to the US Army in Bavaria. (NARA)

February 1942 and, when launched on 18 March 1942, it failed. The second test missile failed on 13 June 1942. The third, A-4V3, lifted off on 16 August 1942 but suffered a string of sub-component failures starting with the electrical supply. Nevertheless, it flew to a height of 11.7km (7¹/₄ miles) before the engine shut down prematurely. The first successful flight occurred on 3 October 1942 with A-4V4, landing 190km (118 miles) away in the Baltic and only 4km (2¹/₂ miles) from the intended target. The test program continued into 1943 with successes mingled with aggravating failures. The launch of A-4V10 on 7 January 1943 was the most dangerous when an explosion in the combustion chamber caused the missile to topple over off its launch pad, engulfing Test Stand VII in an enormous fireball. The launch on 30 June 1943 was even more hair-raising when the missile lost flight controls while still over Peenemünde, and fell uncontrolled on to the neighboring Carlshagen airfield, destroying several Luftwaffe aircraft. Nevertheless, by the end of 1942, the test program had shown that the new weapon was technically viable, and on 22 November 1942 Hitler approved a plan to begin series production.

The success of the Army's A-4 program, and Dornberger's suggestion that the A-4 could compensate for the Luftwaffe's inability to sustain a bombing campaign against Britain, provoked the Luftwaffe to begin its own missile program in 1942, the Fieseler Fi-103 cruise missile, also known as the FZG-76 and later known as the V-1 or Buzz Bomb. The Fi-103 was a very simple, almost crude weapon compared to the

With few fiscal restraints, the A-4 missile development effort expanded in the late 1930s. The program enjoyed a string of critical technological breakthroughs and many of its innovations are still used in missile designs today. The most challenging aspect of the missile design was the inertial guidance platform, which was based on a set of gyroscopes to provide inputs to the flight control system. The first static firing of the powerful new engine took place on 21 March 1940. The design needed considerable refinement not only to overcome technical problems, but to make it suitable for inexpensive mass production.

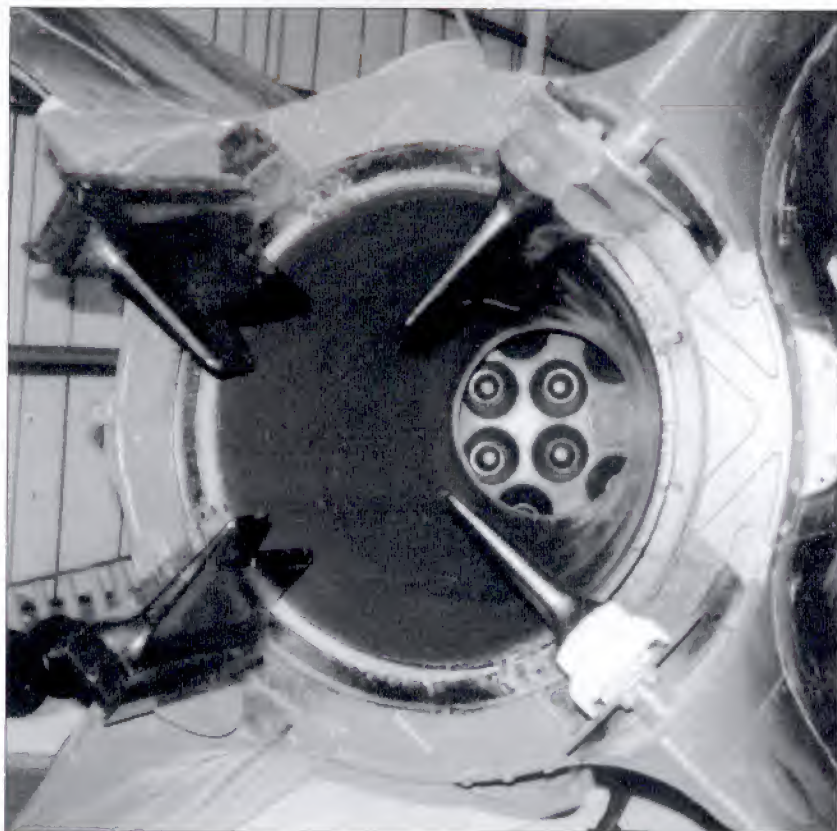
The first test missile A-4V1 (V = *Versuchsmuster*, test vehicle) was ready on 25

sophisticated A-4, but as a result it was also inexpensive to develop and manufacture. At first, the Army worried that the Luftwaffe would try to substitute the Fi-103 for their prized A-4. In late 1942 the new head of the German armament program, Albert Speer, convened a commission of senior officials to debate the merits of both weapons. In May 1943 the commission recommended that both programs proceed. The Fi-103 was not particularly accurate and its modest speed would make it vulnerable to interception and anti-aircraft guns. But it was so inexpensive that it could be fired in large numbers. On the other hand, the

Fi-103 would require a fixed launcher installation which would be vulnerable to bombing attack, while the A-4 could be launched from less vulnerable alternatives, and once launched it would be invulnerable to interception.

The production of both the Fi-103 and A-4 was further reinforced by Germany's declining fortunes on the battlefields. The balance on the Eastern Front shifted decisively in the Soviet Union's favor following the battle of Kursk in the summer of 1943, with the strategic initiative now permanently passing to the Red Army. Hitler and other senior Nazi leaders began to view the Peenemünde secret weapons as a panacea for their strategic failures, dreaming that they could decisively influence the conduct of the war. As a result, the missile program received growing support from the Nazi leadership even though the German armaments industry was hard pressed to manufacture adequate quantities of conventional weapons.

In August 1943 the RAF launched a surprise air raid on Peenemünde. Britain conducted an aggressive and successful technical intelligence campaign to pre-empt German weapons and, although the Germans had gone to great lengths to maintain secrecy about the program, leaks inevitably occurred due to the use of forced labor in the construction of the A-4. In December 1942 a Danish chemist had reported that the Germans had tested a missile capable of flying 300km (186 miles) from a site on the Baltic, a rumor that was repeated by German officers captured in North Africa. The probable location of the test site was narrowed down in early 1943 when the Polish resistance reported to London about German rocket engine development on Usedom based



This view into the exhaust chamber of a preserved A-4C missile shows the graphite vanes used to steer the missile, an innovation in missile design still used on some tactical missiles. (Author)



An A-4B is seen here on a *Meillerwagen* in the experimental June 1943 camouflage scheme. Most of this production run was expended in tests from Peenemünde and Blizna in 1943. (MHI)

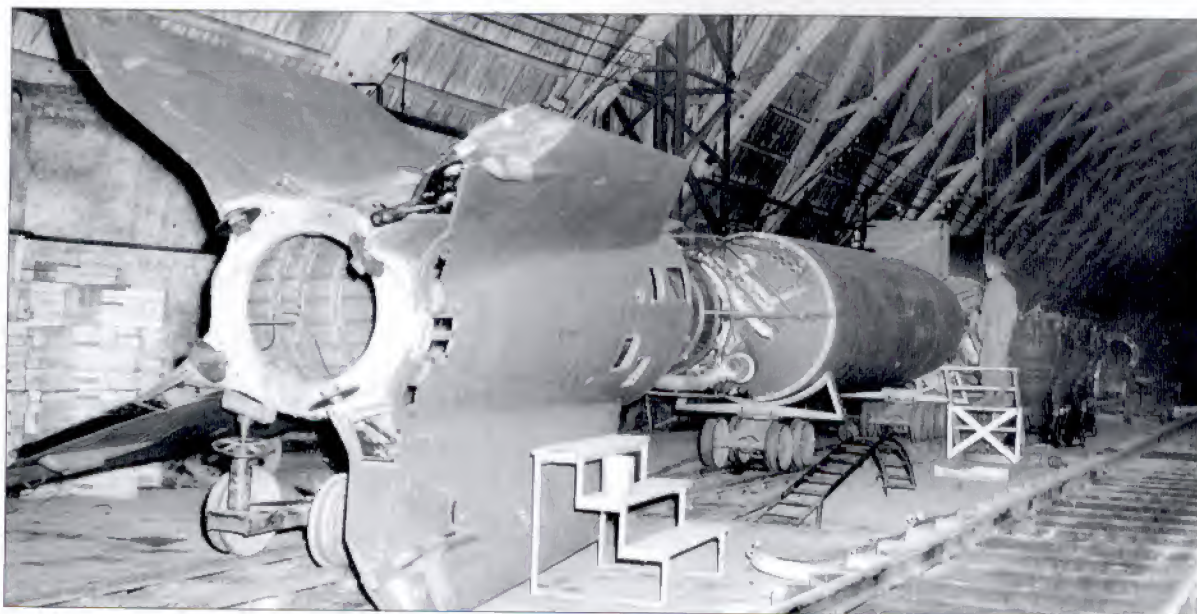
A group of A-4B missiles are seen here at Test Stand X at Peenemünde for training launches by Batterie 444, the original A-4 training unit. They are in the late style test scheme of olive green over a white and black tail. (MHI)



on reports from Poles who were sent there as forced laborers. Far more detailed intelligence arrived in London through the spring from both Polish and Luxembourger workers at Usedom. In April 1943 Duncan Sandys, MP, was appointed to head a special investigation, codenamed Bodyline, to examine the possible missile threat. The reports about the Baltic launch site led to special reconnaissance missions starting in late April 1943. These produced the first hard evidence of the A-4 missile.

Sandys presented the evidence, and on 29 June Churchill approved an RAF Bomber Command strike which took place on the night of 17–18 August 1943. Operation Hydra gave priority to hitting the living quarters of the German missile engineers, presuming that their deaths would most adversely effect the course of the program. The initial wave hit the German housing, but due to problems laying the marker flares, about one third of the aircraft hit the forced laborers' camp a little to the

south. The target of the second wave, the A-4 missile plant, was only partially damaged, again due to incorrect marker flares. The attack included 520 heavy bombers and dropped about 1,875 tons of bombs on the test site, losing 40 bombers in the process. Total casualties on the ground were 735, of whom 213 were forced laborers. The attack failed in its primary mission of decapitating the development program; only two senior engineers were among the dead. It partially succeeded in its secondary mission against the production plant.

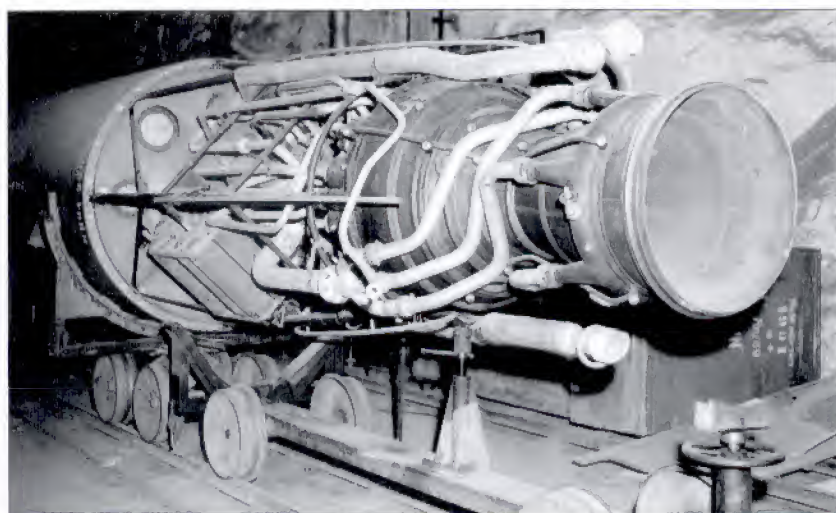


A-4 production

Although Dornberger wanted A-4 production at the Army-controlled plant at Peenemünde, that was opposed by the head of the A-4 industrial program, Gerhard Degenkolb, who had been assigned to the project after having straightened out Germany's troubled locomotive industry. Degenkolb had originally planned to have the A-4 built at three different plants, but the Peenemünde raid made it clear how vulnerable these conventional plants would be to air attack. The Peenemünde plant was downgraded to a pilot production plant and would continue to manufacture A-4 missiles in small test quantities. The other plants already assigned to manufacture the A-4 would continue to manufacture missile components but the final missile assembly would take place at a new underground plant near Nordhausen, run by the new government-controlled Mittelwerk company, which had been formed on 24 September 1943.

The Mittelwerk plant was constructed on the basis of an existing tunnel system used to store fuel. To extend the tunnels sufficiently to create an underground factory required an enormous amount of work, and much of the excavation was initially carried out by inmates from Work Camp Dora, a sub-camp of the nearby Buchenwald concentration camp. The use of prison labor secured the role of Himmler's SS in the A-4 missile program, since the SS controlled the camps and the slave labor force. Management of the Mittelwerk construction was gradually assumed by Brigadeführer Hans Kammler, a civil engineer who headed the construction department of the SS Economic and Administrative Main Office, and who had played a prominent role in the construction of the ultra-secret death camps at Auschwitz-Birkenau, Majdanek, and Belzec. Due to the appalling work and living conditions, the death rate among the prisoners was horrific, with over 3,000 dead by January 1944. Most of the prisoners were Russians, Poles, and French, though the camp held an international assortment from all over Europe. Of the 60,000 prisoners who passed through the Dora-Mittelwerk camps, about

The primary production facility for the A-4 missile was the Mittelwerk tunnel complex near Nordhausen, managed by the SS. The brutal work conditions inside the tunnels led to the deaths of thousands of forced laborers from the nearby Dora camp. (NARA)



A detail view of the rocket engine assembly of the A-4 taken inside one of the production tunnels in 1945 by US Army troops. The pipes beside the main exhaust chamber are exhaust ports for the turbopump. (NARA)

one third died due to disease, starvation, executions, and the death marches in the spring evacuation of 1945. Of these deaths, about 10,000 can be associated with the manufacture of the A-4. More than 5,000 other forced laborers died in other facilities related to the A-4, meaning that more than three times as many people died manufacturing the A-4 than were killed by its combat use.

The first five A-4 missiles were completed at the Mittelwerk plant on 31 December 1943 but their assembly had been so rushed that they had to be returned to the plant immediately for corrective work. The intended production rate at the Mittelwerk was 900 per month, and about half this objective was reached by late spring 1944. However, problems uncovered during field trials resulted in a sharp drop in production during the summer of 1944, and peak production was not reached until the fall after corrective changes were made in the A-4 design.

A-4 MISSILE MANUFACTURE

	Peenemünde	Mittelwerk	Total
To 1944	300	0	300
Jan 1944	30	50	80
Feb	30	86	116
Mar	20	170	190
Apr	15	253	268
May	15	437	452
Jun	15	132	147
Jul	15	86	101
Aug	15	374	389
Sep	15	629	644
Oct	15	628	643
Nov	15	662	677
Dec	5	613	618
Jan 1945	0	690	690
Feb	0	617	617
Mar	0	490	490
Total	505	5,917	6,422

Deploying the V-2: defense by concrete

By the end of 1942 initial steps to deploy A-4 missile units had begun. The most critical bottleneck was the supply of the liquid oxygen (LOX) used in the propulsion system. Total LOX production in Germany and the occupied countries was about 215 tons per day, or about enough for 15 A-4 launches daily if all the production was earmarked for the missiles. Due to industrial demands for LOX, this would not be available, so new sources had to be created. In October 1942 construction began

on three new LOX generation plants providing an additional capacity equivalent to 15 launches per day. The new generation facilities were incorporated into plans for a series of massive bunkers for the preparation and launch of the A-4 missiles against London. The Peenemünde engineers favored fixed sites due to the complexity of the missiles and the need for extensive testing prior to launch. If the missiles were launched from sites distant from the LOX generation plants, an additional 5 tons of LOX would be needed daily to compensate for evaporation, decreasing the maximum launch rate possible. This was an added incentive for locating the missile launchers with the LOX plant.

The Army artillery officers, including Dornberger, did not favor the fixed sites, fearing that they would quickly attract Allied air attack. They preferred to deploy the launchers in mobile field units which could move from place to place to avoid air detection. In spite of Army opinions Hitler approved the bunker option on 29 March 1943. The first bunker was built in the Eperlecques forest near Watten in the Pas de Calais opposite London, under the cover name *Oberbauleitung Nord West* (Northwest Powerplant). The structure was 80m long by 25m high (262½ x 82ft). At a 7 July 1943 meeting at Hitler's headquarters, Dornberger and Speer displayed models of the Watten bunker as well as the proposed mobile A-4 missile launchers. After Dornberger reiterated his preference for the mobile launching option, Hitler rebuked him, stating that they would be vulnerable to air attack. Hitler was convinced that the bunkers would be impregnable like the U-boat bunkers at Brest, and that "every bomb that drops on them is one less for Germany." He ordered Speer to construct more launch bunkers in addition to the Watten missile base.

The Watten bunker could contain 34 missiles and generate enough LOX to conduct four launches per day, plus additional launches if LOX was provided from other plants. By August, there were 4,000 laborers at the site working 24 hours a day. Allied intelligence noticed the construction in May 1943, and by the summer suspected that it was connected with secret weapons. On the advice of civil engineers, an attack was postponed until after the main pouring of concrete had been made but before it had time to dry. On 27 August 1943, 187 B-17 heavy bombers struck Watten, reducing it to a tangle of shattered molds, twisted reinforcing steel and splattered concrete. The German paramilitary construction service, the Organisation Todt, concluded it would be impossible to reconstruct the bunker as planned. However, part of the undamaged walls could be used to create a new, smaller bunker for LOX generation adjacent to it. A new construction technique was devised to cast a 3,000-ton roof as a slab on the ground and then jack it



Another group of A-4B missiles seen at Test Stand X, the two nearer missiles are in the *Gebatikt* camouflage scheme. The disk on the nose is a device to prevent empty missiles from toppling in the wind prior to fueling, and guide wires can be seen leading to the ground. (MHI)



Allied bombing prevented the completion of the Watten missile bunker in its intended form, and the small section completed was used for liquid oxygen production. It was abandoned in the summer of 1944 when the Pas de Calais was overrun by the British 21st Army Group. (NARA)

number of age-expired B-17 bombers into remote-controlled "Aphrodite" drones packed with 15 tons of explosive. A two-man crew flew the "baby" Aphrodite aircraft until it was on course and, after setting the fuzes, parachuted from the B-17. It was then controlled by the "mother" aircraft, a modified B-34 Ventura bomber, which aimed it into the target by radio control. The first four Aphrodites were launched against four missile sites on 4 August including one against the Watten bunker, with little result. Two more Aphrodites attacked Watten on 6 August, again without effect. The program came to an abrupt end when another bomber, piloted by Joseph Kennedy, the elder brother of future president John F. Kennedy, unexpectedly blew up in mid-air shortly after take-off, damaging houses in Britain in a five-mile diameter. The Watten site was captured by Canadian troops on 6 September 1944.

The initial attack against the Watten bunker forced the Organisation Todt to examine options for other launch sites nearby. A limestone quarry near Wizernes was selected in September 1943. The hill overlooking the quarry would be capped with a million-ton concrete dome, and then a launch preparation area would be excavated under it. This would be connected to a series of tunnels called the *Regenwurm-lager* (Earthworm Camp) for the storage of missiles and supplies. After the missiles were fueled and prepared, they would be towed out to the quarry via two tunnels for launch. The bunker complex would be supported by a smaller bunker in nearby Roquetoire fitted with a radio beacon to improve missile accuracy. Construction began at Wizernes in November 1943 and Allied air attacks followed in March 1944 when it was surmised that it was another secret weapons site. On 17 July 1944 RAF Lancasters of 617 Squadron dropped Tallboy bombs, three along the rim of the dome, one under the dome, and another in the mouth of one of the two exit tunnels. Although the dome itself was still intact, it was undermined by the massive bombs and the damage prevented any further work.

Two more bunkers were begun on the Cherbourg peninsula at Sottevast and Equeurdreville in August 1943. These were intended to be launcher bunkers like the original Watten scheme, with the main

into position, minimizing its vulnerability to air raids. Remarkably, the new bunker was completed in January 1944 in spite of further air raids.

Its invulnerability to normal bombs having been recognized, on 30 May 1944 the bunker was attacked by the RAF's 617 Squadron delivering massive six-ton Tallboy bombs. In spite of one hit and several near misses, the structure withstood the attacks. The USAAF took its turn, having converted a



buildings measuring about 30 by 200m (100 x 650ft). Air attacks on the Sottevast site began in February 1944, and less than one quarter of the building was complete when the Cherbourg peninsula was captured by the US Army in June 1944.

The attacks on the bunkers also led to the construction of two alternate liquid oxygen plants, at Schmeidebach in Thuringia and Puckheim in Austria, starting in October 1943.

The Allied air attacks on the large bunker sites reinforced Dornberger's call for the formation of mobile launch units. Deployment plans changed and one stationary "bunker" battalion and two mobile battalions were authorized. Unwilling to give up its involvement in the prestigious A-4 missile program, the Organisation Todt began building a series of small launch sites for the mobile battalions consisting of simple concrete hard-stands for the launch pads, reinforced trenches for the support vehicles, with a small number of inconspicuous handling buildings. Construction of these sites on the Cherbourg peninsula was begun, but they were never used as the area was captured after the Normandy landings in June 1944.

Development problems

While the launch sites were being constructed in France, the first missile units were being trained at Peenemünde. The Lehr und Versuchsbatterie 444 (Training and Experimental Battery 444) was created at Köslin near the main test center in July 1943. But in the wake of the August 1943 air raid, it was transferred to the more secure Waffen-SS Heidelager training ground, a former Polish artillery range near Blizna. Batterie 444 began field launches of early production A-4 missiles starting on 5 November 1943. The 300 A-4 missiles in the initial pilot series were designated A-4A and were manufactured at the Peenemünde pilot plant in 1943. These were followed by the series production A-4B which incorporated changes to simplify and rationalize the design.

The training launches were a fiasco. On several occasions, the missile engine failed shortly after launch, and the missile toppled over and

Following the bombing of Watten, a second missile bunker complex was started at the Wizernes lime quarry. The concrete dome over the preparation chamber was completed along with a ventilation tunnel seen to the left. However, repeated Allied bomber attacks prevented its completion. This site has been preserved as a museum. (NARA)



The Sottevast missile bunker near Cherbourg was configured like the Watten bunker, but using construction techniques to minimize the risk of Allied air attacks. Only this section was completed by the time the area was captured by the US Army in June 1944 after the Normandy landings. (NARA)

destroyed the launch pad. Others lifted off properly but then exploded overhead. The most alarming results were with the missiles that had flown the full range. Most broke up in flight during the final descent. Up to the end of March 1944, when the A-4 was supposed to be ready for combat, there had been 57 launches at Blizna of which only 26 actually got into the air. Of these, only 7 actually reached the ground and only 4 in the target area. Not a single missile with a functional warhead had impacted; all had disintegrated in the air. The reasons for the disintegrations in the final descent were a mystery since there was no adequate telemetry equipment available for monitoring the final phase of the flight, and no adequate tracking systems in the impact area.

At first, it was thought that the problem was due to heat-related structural failure induced by the effects of the super-cold liquid oxygen tank combined with the heat of the terminal dive. After launch, the A-4 climbed into the frigid temperatures at the edge of space and then descended at high speed moments later, with the fuselage becoming cooked to 805 degrees Celsius (1,560 degrees F). To circumvent this problem, the fuel tanks were insulated with fiberglass in the

A-4C version which entered production in April 1944. Although this did reduce the failure rate, it did not solve the problem. Finally, "tin trousers" were added to the forward section, a type of reinforcing ring. A further series of 80 test shots using modified A-4C missiles began on 30 August 1944. These demonstrated that the "tin trousers" were effective, though the final series of tests had to be moved north-westward to the Heidekraut base in the Tuchola forest in Poland because of the advance of the Red Army.

The Polish Home Army resistance monitored the various test flights and tried to capture pieces of the missiles to pass on to Britain. Late in May 1944 an A-4 crashed in fairly intact condition near the River Bug to the east of Warsaw and was secured by the Home Army before it was located by German recovery teams. British intelligence was very interested in examining the missile since it was presumed that it employed some form of radio-command guidance that could possibly be jammed. As a result, an RAF C-47 Dakota flew a daring mission from Brindisi in Italy to Poland on the night of 25/26 July to pick up key parts as well as documents prepared by Polish engineers. A second A-4 became accessible when one fired from Peenemünde ended up crashing in Sweden on 13 June 1944. The Swedes prepared a technical report on the missile which was surreptitiously provided to the Allies, and the British and American air attachés were allowed to inspect the missile on 6 July 1944, and later to take portions of it. In the end, neither captured example proved of much help in developing countermeasures since the inertial guidance was not subject to radio countermeasures.



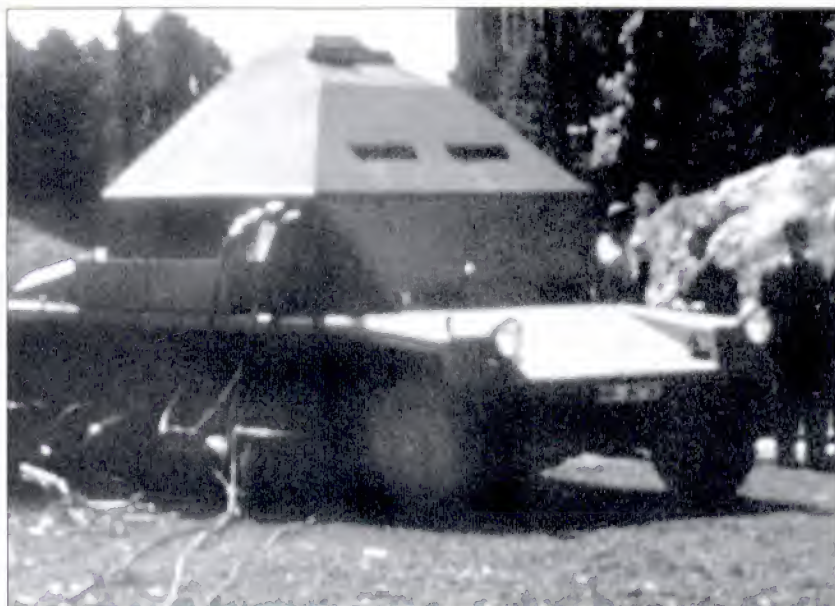
One of the first glimpses of the V-2 obtained by Allied intelligence was this photo of a V-2 engine included in a technical report obtained from Sweden after one accidentally crashed there in June 1944. This photo and the rest of the report was kept secret for many years after the war because of Swedish neutrality. (NARA)

A-4 MISSILE UNIT ORGANIZATION

In the fall of 1943 it appeared to the Germans that both the A-4 ballistic missile and Fi-103 cruise missile would be ready for combat in the spring of 1944, and so the first steps were taken to organize a field formation. Since both weapons were designed to bombard Britain, on 1 December 1943 the Army operations staff created a hybrid organization, the 65. Armee Korps zur besonderen Verwendung (65th Army Corps for Special Employment), which would be staffed both by Army and Luftwaffe officers. Command of the 65. Korps was given to Generalleutnant Erich Heinemann, previous commander of the Army artillery school, and the chief of staff was a Luftwaffe officer, Oberst Eugen Walter. The corps set up its headquarters at St Germain in France in early 1944, but because of the problems in the A-4 program, it concentrated on the deployment of the Fi-103/V-1 cruise missile. The Army missile batteries were initially commanded by Dornberger, who as of 1 September 1943 was relieved of responsibility for the A-4 development program, and reassigned as the Army missile commander. However, the disastrous trial firings of the A-4 in Poland led to Dornberger's frequent absence from the headquarters in France. General Heinemann was not happy with the amateurish organization of the early missile units and replaced Dornberger with an experienced field artillery officer, Brigadier General Richard Metz, with Dornberger remaining in charge of the technical aspects of the A-4 missile program. The new commander realized how difficult it would be to operate such a revolutionary weapon in the field, and therefore set about trying to make the operations as simple as possible.

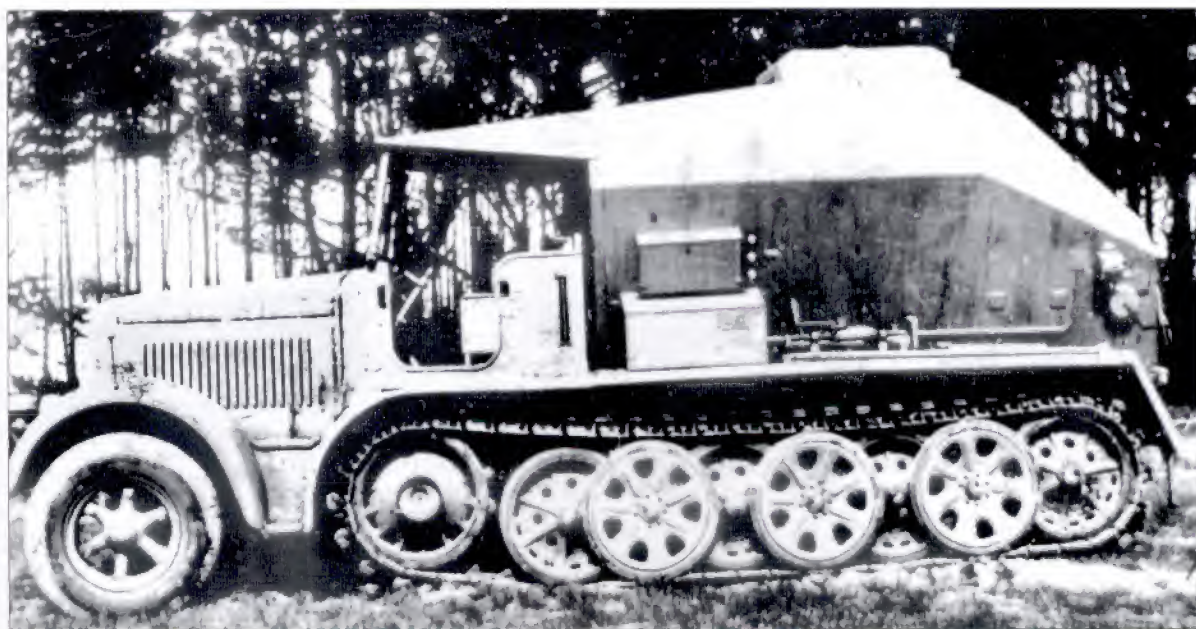
In early 1944 the A-4 force consisted of the Long-Range Missile School in Köslin, Batterie 444 conducting the test launches at Blizna, and Replacement Training Battalion 271 at Schneidemühl. Three launch battalions were formed, Artillerie Abteilung 836 (Mot.) at Grossborn in September 1943, Art. Abt. 485 (Mot.) at Naugard in November 1943, and Art. Abt. 962 (Mot.) on 14 December 1943. Brigadier Metz inspected the first two battalions in late March 1944 and

The first version of the armored fire control vehicle for the A-4 missile was this type built on a Bussing-Nag HKp 902 5-ton half-track. This vehicle was used at Peenemünde, but was not produced in series. (USAOM, APG)



sent back a scathing report. The commander of Art. Abt. 836 was "useless, idle, talkative, self-important, and a fool," while the Art. Abt. 485 commander was "not up to his job." Both units were so short-staffed that the third battalion was cannibalized to provide troops for the others. Neither had its actual launch equipment until May, which delayed training. Metz was so discouraged by the poor state of training and the immature technical state of the A-4 missile that he asked to be transferred back to a real command at the front. In the meantime, with Hitler giving so much attention to the new secret weapons, the head of the SS, Heinrich Himmler, ordered the Waffen-SS to set up its own missile unit, and SS Werfer-Abteilung 500 began converting from their conventional

The production version of the armored fire control vehicle for the A-4 batteries was built on the SdKfz 7 8-ton half-track. (NARA)



artillery rocket launchers to the A-4 in the spring of 1944.

The Allied landings in Normandy and the delay in fielding the A-4 missile undermined all the efforts that had gone into constructing A-4 sites near Cherbourg and in the Pas de Calais. Although the Allies did not actually capture all the A-4 bunker complexes until early September, on 17 July Hitler authorized the abandonment of the

Watten site, the down-sizing of the Wizernes bunker to liquid oxygen production, and the creation of three new firing positions closer to Germany that would allow the A-4 battalions to fire from bomb-proof shelters. The instructions were overtaken by events when the Allies overcame the stalemate in Normandy in late July 1944 and thrust over the River Seine past Paris in late August.

The attempted coup against Hitler on 20 July 1944 completely changed the organizational structure of the missile force. Hitler became paranoid about treachery in the upper ranks of the armed forces, and no longer trusted them to control his new wonder weapons. Himmler and the SS had already made attempts to take over the prestigious missile program by controlling the production at the Mittelwerk, but had failed to gain total control of development activities at Peenemünde. SS Lieutenant General Hans Kammler, already in control of Mittelwerk, was appointed as Special SS Commissioner for V-2 Operations in August 1944 and gradually usurped tactical control of the missile units. On 2 September 1944 control of the A-4 missile units was taken out of the hands of the 65. Korps and put under Kammler. He reorganized the existing A-4 units into two regional commands, Gruppe Sud, based around Art. Abt. 836, and Gruppe Nord, based around Art. Abt. 485 and Batterie 444, freed up from its testing role at Blizna.



The prescribed practice was to deploy the armored fire control vehicle in a revetment about 100m (330ft) from the missile launch pad to prevent injury to the launch crew in the event that the missile blew up near the pad. This is an example of the practice by a Red Army crew during firing trials in 1947 at Kapustin Yar. (A. Aksenov)

Launching the A-4

At the outset of the missile campaign in the fall of 1944, each A-4 launch battalion consisted of five sections: a headquarters section, launch section, radio section, technical section, and fuel section. The launch section had three launch batteries each with three *Meillerwagen* transporter-erector trailers, one *Bodenplatte* launch platform and one fire control vehicle. Each launch battery had 39 troops assigned in five teams: fire control team, survey and adjustment team, engine team, electrical team, and vehicle/trailer team. The radio section was responsible for unit communications, and conducting the site survey to locate the launch batteries. The technical section was responsible for unloading missiles from the railroad supply point, and preparing and transporting them to the launch site. This section had three Vidal

trailers for each *Meillerwagen* for transporting the A-4 missiles, so there were 27 per battalion. The fueling section was divided into three teams, handling liquid oxygen, alcohol, and sodium permanganate (Z-Stoff). The battalion had 22 LOX trailers, 48 alcohol tank trucks, 4 hydrogen peroxide trailers, and 4 pump trailers.

The start of the launch process began with the shipment of the missiles to the launch area by train. The technical section removed the missiles from the train using a De Fries/Sirabo 16-ton crane. These were loaded on to a Vidal trailer and were then towed to a preparation area near the launch site for further work. The A-4 field manual warned the crews that the missiles had to be treated as gently as eggs, as any rough handling could damage fuel lines and delicate parts, rendering the missile unflyable. The missiles came without warheads, which were shipped separately, and these were usually fitted at the preparation area. The technical section performed necessary checks on the missile and, once these were completed, the missiles could then be transferred to the transporter-erector trailer, again using a Strabo crane. This trailer was officially designated as the FR-Anhänger (S) but it was more popularly called the *Meillerwagen* after its manufacturer. Liquid oxygen was delivered in a special insulated tank car, and transferred to smaller insulated trailers.

Once the missile was loaded on the *Meillerwagen*, it was towed to a pre-surveyed launch site. The ideal site was a road with trees on either side to provide camouflage during the lengthy process of erecting, fueling, and launching the missile. On arriving at the launch site, the Bodenplatte launch platform was positioned behind the *Meillerwagen* and lowered from its two-wheel semi-trailer. Once the missile was in position, the cable trailers and power supply trucks moved to the site and the power connections were made to the missile and the trailer. Once power was provided to the *Meillerwagen*, it took 12 minutes to erect the missile. The *Meillerwagen* remained on the site through the fueling process since it doubled as an inspection scaffold with ladders built into its erection arms. It was then pulled away from the

missile and its working platforms were unfolded against the missile to permit electricians to open the hatches in the control compartment and insert the ground plugs. As the preliminary preparations were completed, the rest of the 32 vehicles and trailers associated with launch moved into position around the missile site.

With the missile on the launch platform and connected to the power supply and control

The A-4 missile was launched from an elevated, mobile launch stand that could be towed into position using a two-wheel semi-trailer. It is seen here being towed into position by an armored fire control half-track, but this was not standard practice. (NARA)

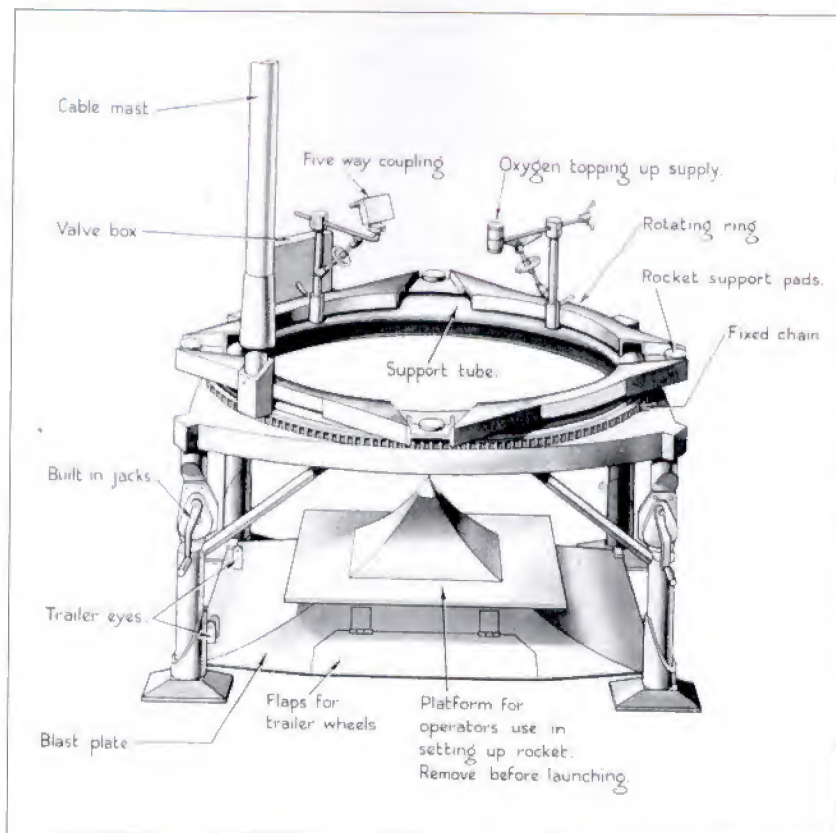


vehicles, some preliminary tests were conducted on the missile such as a dry purge of the fuel tanks to make certain that no leaks had developed since the missile had been shipped. Delicate assemblies such as the graphite control vanes were attached to the missile, and protective covers removed. Once the missile was ready, the fuel trucks and trailers were then moved into position around the missile in a standard pattern. Two methyl alcohol tankers were used to fill the main fuel tanks, taking about ten minutes. The liquid oxygen trailer would perform its loading function as late as possible in the launch preparation, to minimize the amount of liquid oxygen evaporating in the missile. The missile

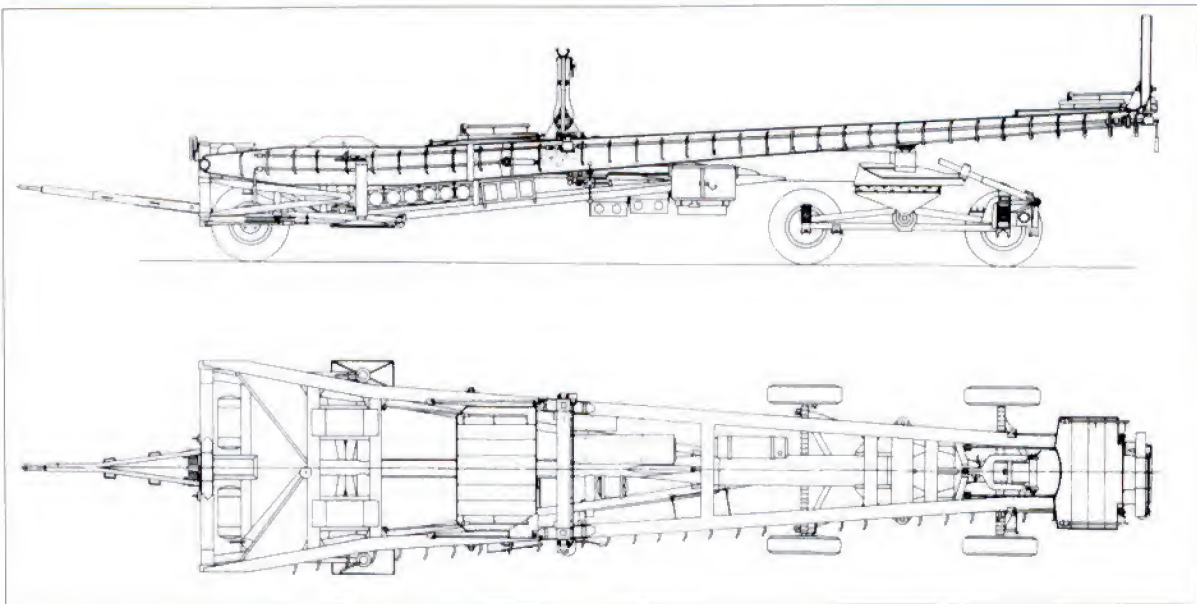
turbopump used to feed the alcohol and liquid oxygen into the combustion chamber required its own fuel supply, consisting of sodium permanganate and hydrogen peroxide. Once the fueling process was complete, an electrical igniter was inserted below the combustion chamber of the rocket engine. During the fueling process, a crew member would climb up to the guidance port on the upper fuselage and connect an electric cable that fed commands to the Vertikant inertial guidance unit and flight control system.

With the fueling and preparations complete, the *Meillerwagen* arm would be lowered and the trailer towed away, while at the same time the supply vehicles would be driven a safe distance from the launch site. The last process in the launch preparation was the final adjustment to the launch platform done using conventional artillery theodolites to make certain that the missile was oriented in the proper azimuth. Once complete, the launch commander would announce "X-10", meaning ten minutes to launch time. The process of preparing the missile for launch took four to six hours of which the final 90 minutes were spent actually erecting and fueling the missile at the launch site. About 15 percent of the missiles erected and fueled could not be launched due to malfunctions or icing problems caused by the liquid oxygen.

The Feuerleitpanzer fire control vehicle, a SdKfz 7 half-track with an armored shelter on the rear, would be positioned 100 to 150m (110 to 164 yards) from the missile launch pad, behind a protective berm if time permitted. The protective measures were intended to shield the crew in case the missile collapsed on the pad and exploded, a not uncommon



This illustration from an Allied technical intelligence report shows the details of the launch pad and the function of the various devices. The upper assembly permitted the traverse of the missile during fueling. (MHI)



The transporter-erector trailer was officially designated as the FR-Anhänger (S) but it was more popularly called the *Meillerwagen* after its manufacturer. (MHI)

event with the early A-4. The control vehicle had a crew of four: the launch commander or his deputy, the radio panel engineer, the propulsion unit engineer, and the power control engineer. After monitoring the three control panels inside the armored shelter to make certain that all systems were functioning, the countdown would begin. The launch sequence began by starting the turbopump, which fed liquid oxygen and alcohol into the combustion chamber where it was ignited by a spinning electrical igniter. At this stage, the engine was developing about 8 tons of thrust, not enough for lift-off. When it was evident that the rocket engine was performing properly, the rocket engine would be switched to full thrust, causing the missile to begin its ascent off the launch pad.

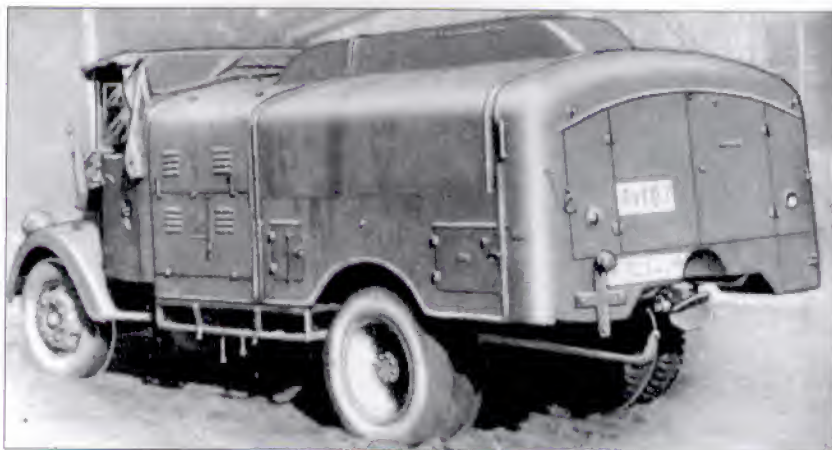
After launch, the A-4 rocket engine operated for up to 55 seconds. Flight corrections were made by the four graphite vanes located beneath the engine's combustion chamber for azimuth and pitch control, and by a set of rudders on the stabilizing fins for roll and yaw. The A-4 missile had provision for a Lorenz *Leitstrahlstellung*, a type of radio receiver connected to the autopilot system, and this was fitted to the final quarter of A-4 production. When this was used a ground radio station emitted a pair of signals which overlapped to form a precise directional signal. This was picked up by a trailing antenna on the missile fin, and the data inputted to the flight control system during the ascent phase of the flight for azimuth correction to improve the accuracy of the missile. However, the ground control equipment was not available until January 1945, and the only unit to use this system regularly was the SS *Werfer-Abteilung 500*, which was given favored treatment in equipment.

The range of the missile could be altered by changing the engine burn time. On the initial batch of missiles launched in the fall of 1944 the burn time was controlled from the ground via radio command signals to an onboard fuel control receiver. During the last five months of the campaign an on-board integrating accelerometer determined when a specific speed had been reached, and then switched off the engine. At the time of engine

cut-off at maximum range the A-4 missile was at an altitude of 30.5km (19 miles), 27.3km (17 miles) from the launch site. Its maximum speed was 172m/sec (492ft/sec.) which decreased to 129m/sec (370ft/sec) when it coasted to its apogee. When flying to its maximum range of 320km (200 miles), the A-4 reached an apogee of 93.3km (58 miles) before plunging to earth on a ballistic path. The flight time at full range was five and a half minutes. The A-4 had very poor accuracy by modern standards, with a standard deviation of 7-17km (4-11 miles) from the intended target. Only about 4 percent of the missiles fell in the intended target area of 3 miles by 4 miles. A significant source of the inaccuracy was the unintended variation in efficiency of the engine combustion which affected the missile velocity.

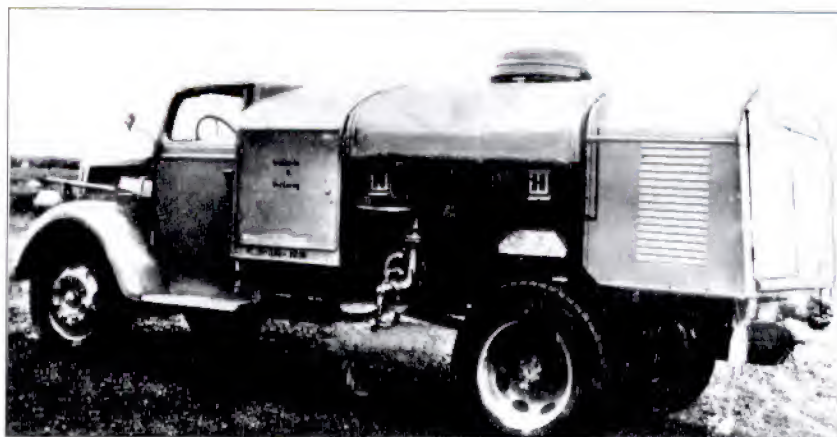
Besides having poor accuracy, the A-4 had a high failure rate due to subcomponent problems, on-board fires, missile disintegration during the terminal dive, and other problems. About 4 percent of the missiles failed to climb properly after launch, this usually occurring within the first 30 seconds of flight. While some of these fell back on to the launcher, most often they fell some distance from the launch site. About 6 percent of the missiles suffered air-bursts due to a premature detonation of the warhead, or a disintegration of the fuel tanks and subsequent explosion. A larger percentage suffered mid-air disintegration, usually in the terminal descent, due to structural failure induced by the heat of re-entry or axial sway, which caused the missile to tumble and break apart. In some of the latter cases the warhead would still impact and detonate, however. Of the 1,152 fired at London, only 517 fell in or near the city, for a probability of hit of less than 45 percent. In the event that the missile did reach its target, it impacted at a speed of 1,290m/sec (3,700ft/sec), about three times the speed of sound.

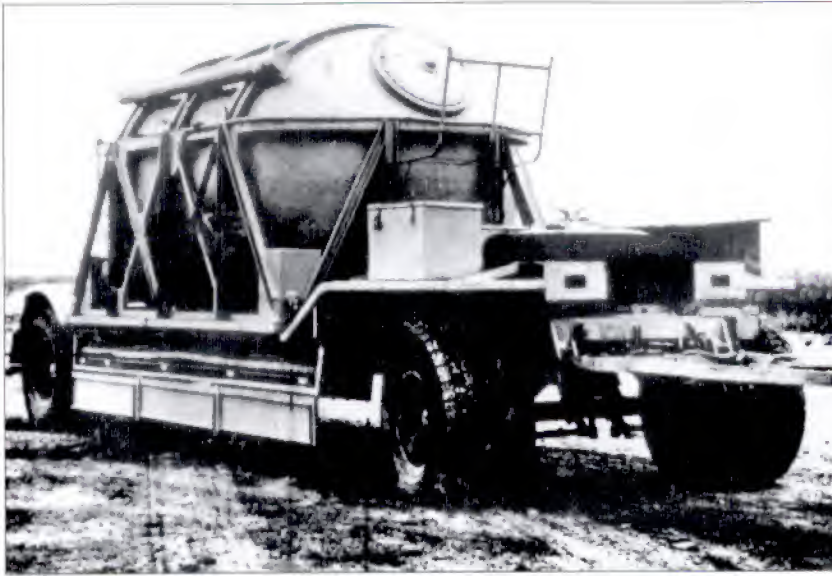
The warhead was a blast type with impact fuzing. The warhead was filled with cast 60/40 amatol, one of the least powerful blast fillings available. This was forced on the designers because of the relative insensitivity of this type of explosive to the heat generated during missile re-entry. The fuzing system on the missile was very



The Kessel-KW.3500 1. B-Stoff was the tanker used to provide alcohol to the missile during the fueling process. It was based on the standard Opel 3-ton KW Kfz 385 tanker used by the Luftwaffe for airfield refueling. (NARA)

The Kessel-KW.2100 1. T-Stoff was the tanker for delivering the hydrogen peroxide oxidant for the engine turbopump, and was based on the Opel Blitz truck. (NARA)





The A-Stoff Anhang 6 was the insulated trailer used to deliver liquid oxygen to the launch site. It was usually towed by a Hanomag SS-100 wheeled tractor. (NARA)

Operation Pinguin

The first operational use of the A-4 missile was delayed until early September 1944 by the development problems uncovered at Blizna. By this time, the A-4 had assumed its best known designation as the V-2, an abbreviation of its propaganda name *Vergeltungswaffe 2*, or Vengeance Weapon 2. At this time, the German Army was in full retreat with the Allies reaching Belgium in early September, and entering Germany in the Eifel region near Aachen by the middle of the month. As a result, the nearest German-held locations to London were in Belgium and the Netherlands. Although the original intention had been to employ the V-2 principally against London, the altered strategic situation led to its use against Allied targets in France and Belgium as well as Britain. The V-2 operations were given the codename Operation Pinguin (Penguin).

The first unit in the field was Batterie 444, which deployed near Baraque de Fraiture in Belgium in early September. It attempted two launches against Paris on 6 September 1944, both of which failed due to engine misfires, and the deployment in the area was complicated by skirmishes with Belgian resistance units. The battery redeployed to the Beuleu woods between Sterpigny and Gouvy and the first successful launch occurred at 0834hrs on 8 September, against Paris. The fate of this missile is not known, but it probably disintegrated during the descent. A second missile was launched at 1100hrs, and it struck in the Charentonneau section south-east of Paris, killing six people and injuring a further 36.

Batterie 444 was followed by Batterie 2, Art. Abt. 485, which moved to The Hague on 3 September 1944 to start missile launches against London. The battery fired two missiles almost simultaneously at 1837hrs from the Wassenaar area of The Hague, aimed at a target point a kilometer east of Waterloo Station. One missile impacted on Staveley Road, Chiswick, in west London and the second in Epping, 27km (17 miles) north of the city centre. The attacks continued at a slow rate from The Hague, even after another battery arrived on 10 September. The launch rate was limited by the supply of liquid oxygen, and many of the

sensitive, and Allied ordnance teams only found two occasions when an A-4 warhead failed to explode. When the missile struck on open ground, the missile explosives combined with the impact speed created a crater 10m (33ft) deep and 12–15m (40–50ft) in diameter. Damage to buildings was largely dependent on the type and construction of the building, but the missile typically penetrated the entire building and detonated on impacting the ground below.



A standard piece of equipment in the A-4 battery was the De Fries/Strabo 16-ton crane, which was used to unload the missiles from the rail cars and for many other heavy handling tasks. (A. Aksenov)

missiles were unusable due to their deterioration during storage. Two batteries of Art. Abt. 836 went into action from Euskirchen near Bonn in western Germany on 15 September; their missiles were mainly aimed at cities in France such as Lille. On 16 September Batterie 444 moved to the Dutch coast near Walcheren to add to the bombardment of London.

Allied countermeasures against the missile sites were made almost impossible by their mobility. RAF fighters strafed the initial site at Wassenaar on 9 September, and the area was subjected to a bomber attack on 17 September. Operation Market-Garden in the neighboring area of the Netherlands was more disruptive to the batteries, and Art. Abt. 485 finally had to pull back into Germany late on 18 September due to the threat posed by Allied ground forces. On 17 September General Kammler's headquarters at Berg an Del was nearly captured by the US paratroopers from the landings near Nijmegen. For a few weeks London was therefore spared further attacks after the launch batteries had been forced back by Market-Garden. During this first phase of Operation Penguin, 43 A-4 missiles were launched, 26 against London and 17 against other targets, mainly in France.

Kammler refused to halt attacks on Britain, which were viewed as the primary mission of his force, so he ordered Batterie 444 to Rijsterbos from where it could attack Norwich and Ipswich. Of the 44 missiles launched from 23 September to 12 October, 37 reached England, but the results were negligible. Art. Abt. 485 moved to Burgsteinfurt in Germany and resumed missile attacks on cities in France and Belgium. Once the fighting around Arnhem tapered off, one of its two launch batteries was moved back to The Hague and resumed launches against London at midnight on 3/4 October. During the second phase of Operation Penguin, 162 A-4 missiles were launched of which 52 were aimed at England. The average launch rate increased to 6.5 missiles per day.

On 12 October Hitler ordered that the units stop wasting their missiles on secondary targets. Instead, the batteries were to concentrate their attacks on London and the vital port city of Antwerp. While the bombardment of London was intended to break the will of the British people, the Antwerp attacks had the tactical objective of destroying the port facilities to prevent their use in supplying Allied forces.

Final preparations are made in the guidance section of an A-4C missile during operations in the early winter of 1945. This is one of a handful of photos taken of the A-4 missile batteries during combat operations in 1945. (NARA)





An A-4 missile nearly ready for launch. The *Meillerwagen* trailer was towed away before launch and all that remained was the missile and launch pad. The cable connecting the missile guidance section to the fire control vehicle is held aloft by a mast attached to the launch pad. (NARA)

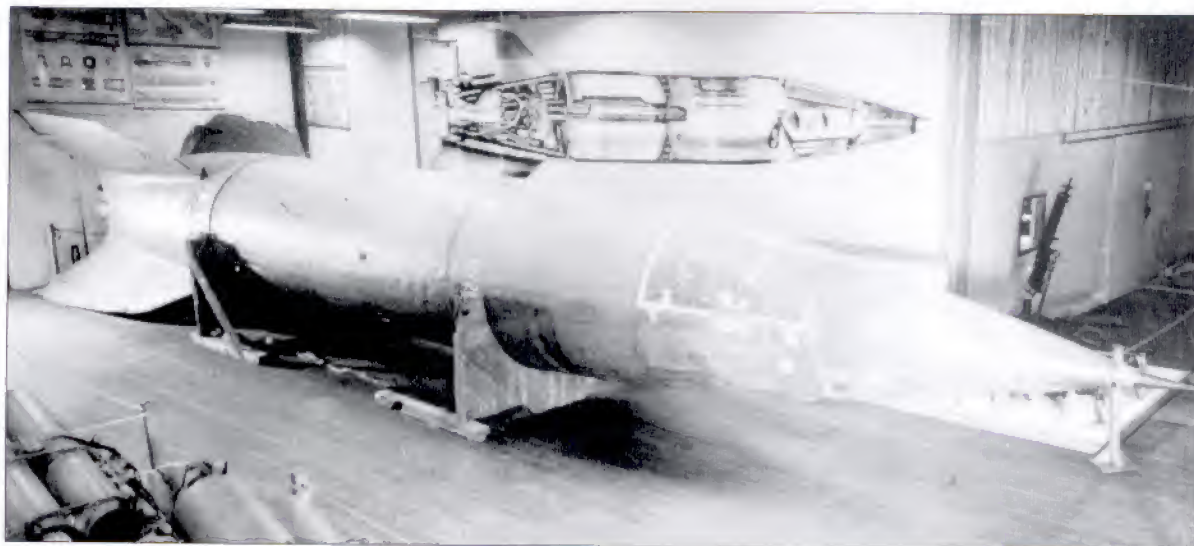
Following the start of A-4 attacks, the organizational structure of the missile force changed again. Kammler's staff lacked the technical training to handle such sophisticated weapons. For example, his operations officer badly fumbled the original deployment of the missile units, and wrecked many of the specialized alcohol tankers by ordering them filled with gasoline. With the SS now firmly in control of the A-4 program, Himmler ordered the Army High Command to organize a proper divisional staff for Kammler. The A-4 batteries were taken from 65. Korps, and placed under Kammler's new command, called Division zbV (*Division zur besonderen Verwendung*: Special Purpose Division). At this stage, Kammler had 24 launch sections under his command.

The second adjustment instituted in October was to change the way that A-4 missiles were delivered to the launch batteries to reduce their high failure rates. During the first two months of launches it was found that 12 percent of the missiles that arrived at the batteries had so badly deteriorated in storage that they had to be immediately rejected, and after further preparation work 57 percent were found to be unserviceable. As a result, a new process called the "Hot Cakes" system was introduced to ensure that the missiles were fired as soon as possible after leaving the factory. Once the missiles left the Mittelwerk, the train was sent to a "Complete Equipment Station" in Germany where additional cars with the proper

number of warheads, Z-Stoff, fuzes, and other components were added. The train then proceeded to the firing units, and the missiles were expended within three to four days of leaving the factories. This meant that about 500 missiles that had been accumulated in warehouses in Germany had to be scrapped or cannibalized for parts.

With this reorganization complete, the third and main phase of missile operations began. Group North was reinforced with SS Werfer-Abteilung 500 and another battery of Art. Abt. 285. These units were divided between the Burgsteinfurt area in Germany targeting Antwerp, and The Hague targeting London. One of the worst A-4 strikes occurred on 25 November 1944 when an A-4 struck a Woolworths store in east London, killing 168 people.

Group South at the time was smaller, based primarily around Art. Abt. 836, firing first from the Merzig area against Antwerp, and later moving to the Hermeskiel area. At the end of November the battalion began moving back over the Rhine due to US Army advances, and the capture of the liquid oxygen plant at Wittlingen severely curtailed launches for most of December. The most intense attacks on Antwerp and neighboring Belgian cities such as Liège coincided with the German offensive in the Ardennes since Antwerp was the ultimate objective of that operation. From 14 December 1944 to 4 January 1945 an average of 100 missiles per



This A-4C is one of a number of V-2 missiles captured by the US Army and later displayed at the Ordnance Museum at Aberdeen Proving Ground. It provides a rare view of a combat missile with the fuze on the nose of the missile. (USAOM, APG)

week fell on Antwerp. By the end of 1944, a total of 1,561 A-4 missiles had been launched of which 491 (31 percent) had been aimed at Britain, 924 at Antwerp (51 percent) and the rest at various cities in France and Belgium. By December the rate of launch failures had fallen to about 9 percent, most often due to a failure in the flight control system. The launch failures were a significant threat in the Dutch towns from which the missiles were launched. The missiles most often failed in the first minute of flight, falling into the towns and exploding with a nearly full load of fuel. The random destruction in The Hague became so bad that German civil authorities recommended halting the launchings from that city. Their pleas were ignored by Kammler.

January 1945 saw yet another reorganization of the A-4 missile force in the hopes of streamlining the awkward and improvised command structure. Art. Abt. 836 became Artillerie Regiment 901 z.V. (Mot.) and took over the functions of the former Group South headquarters. By this stage, it had three complete battalions under its command. Art. Abt. 485 became Art. Regt. 902 z.V. (Mot.) and took over the functions of the Group North headquarters. It had four battalions, including SS Werfer-Abteilung 500 which had been enlarged to full battalion size.

The New Year also saw the first attempts to improve A-4 accuracy using the Lorenz Leitstrahlstellung. The first deployment of mobile beam guidance vehicles began on 28 December 1944 near Dedemsvaart in the Netherlands when the launch batteries of SS Werfer-Abteilung 500 were located in and around Hellendorn. This site was abandoned three days later for Hessum where the unit remained for most of January. The month of February was one of the periods of most intense A-4 launches, many conducted from the Duindigt racetrack in The Hague. Curiously enough, on 14 February 1945, an RAF Spitfire patrolling over the city was sufficiently close actually to fire on a missile rising skyward, but no hits were recorded. The pace of attacks against London increased in February and March 1945, reaching a peak of about 60 missiles per week.

The British response to the launches from the Netherlands was measured, as there was an understanding between the British and Dutch governments to minimize civilian casualties. For example, although the

A: Early German test rockets

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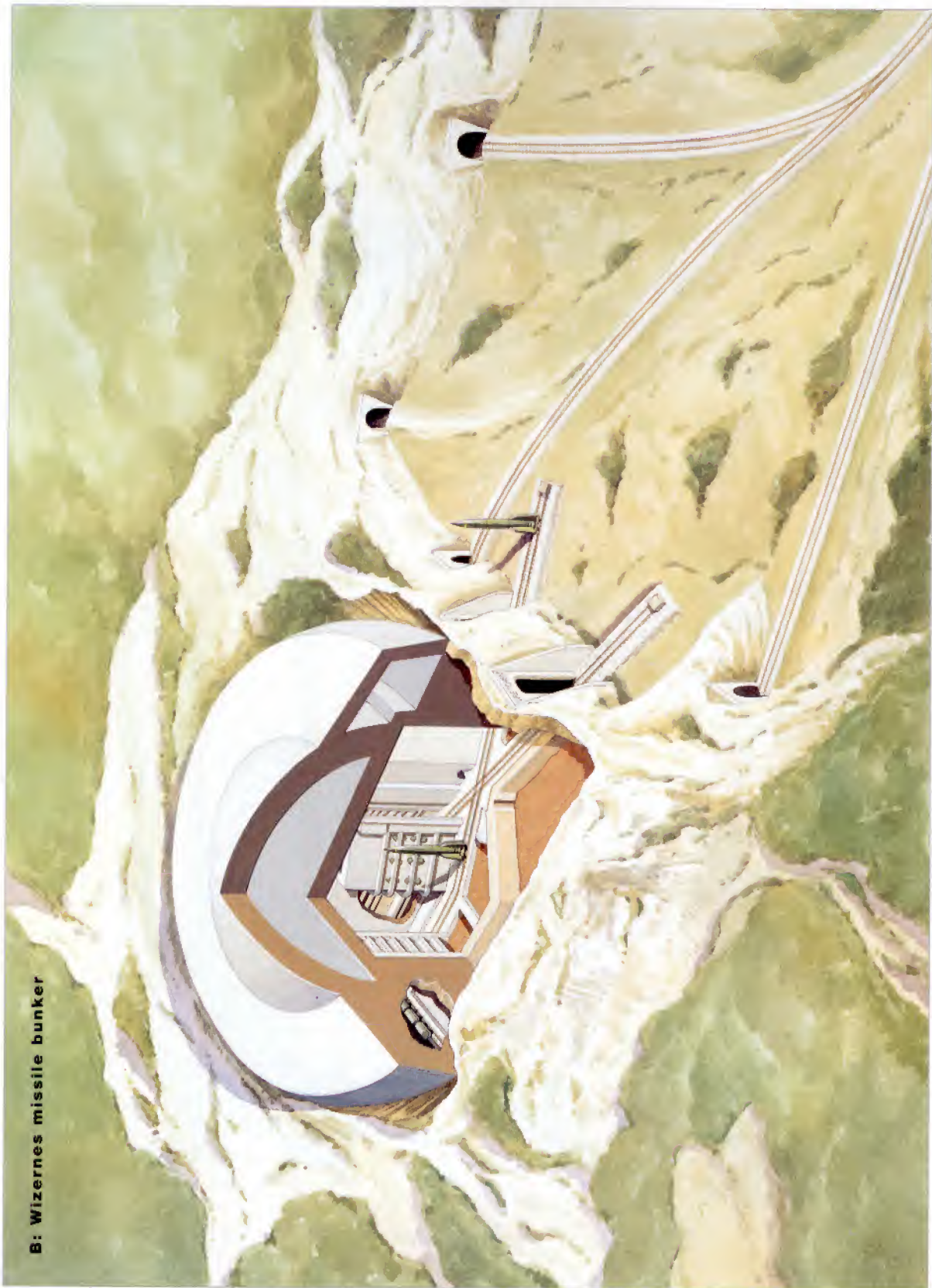
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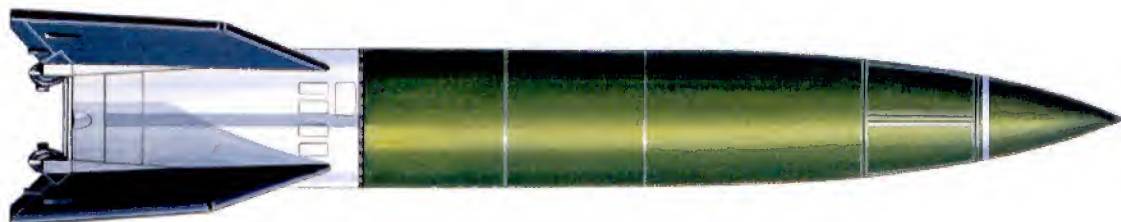
3



B: Wizernes missile bunker



C1: Peenemünde late test scheme



C2: A-4B Batik camouflage scheme



D: CROSS-SECTIONAL DRAWING OF V-2

SPECIFICATIONS

Length: 14m

Diameter: 3.6m (fins); 1.64m (fuselage)

Launch weight: 12,417kg

Empty weight: 3,835kg

Fuel weight: 3,450kg (methyl alcohol); ~4,955kg

(A-Staff: LOX); 172kg (T-Staff: hydrogen peroxide); 13kg (Z-Staff: sodium permanganate)

Warhead: 975kg blast warhead with impact fuzing with 730kg cast 60/40 Amatol high explosive filling

Guidance: Inertial with gyros for roll, pitch, yaw and azimuth control; range control by integrating accelerometer

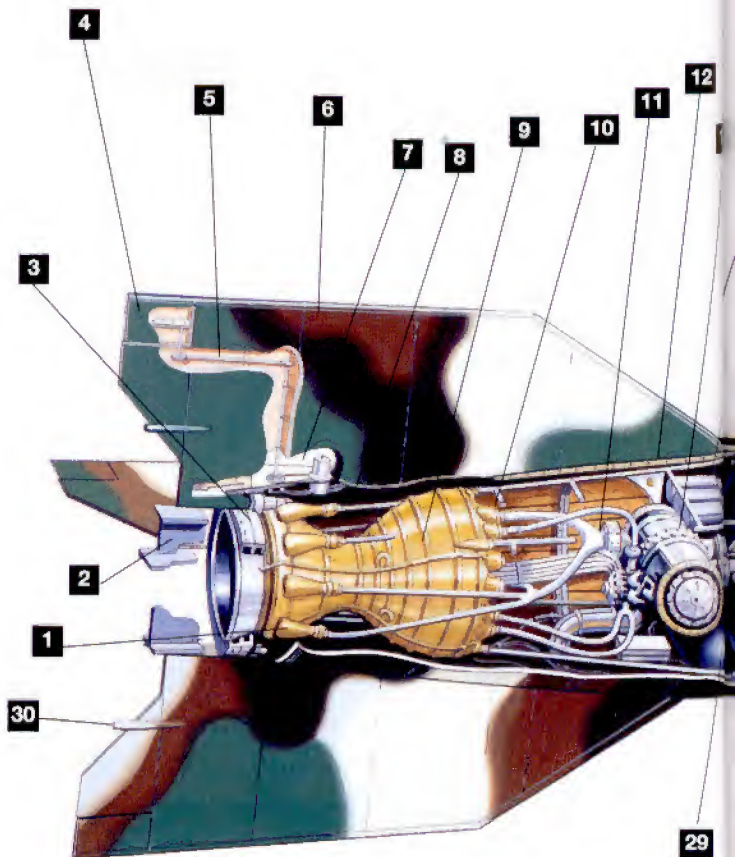
Control surfaces: four graphite vanes in rocket efflux for pitch and azimuth; four rudders on fin for roll and yaw

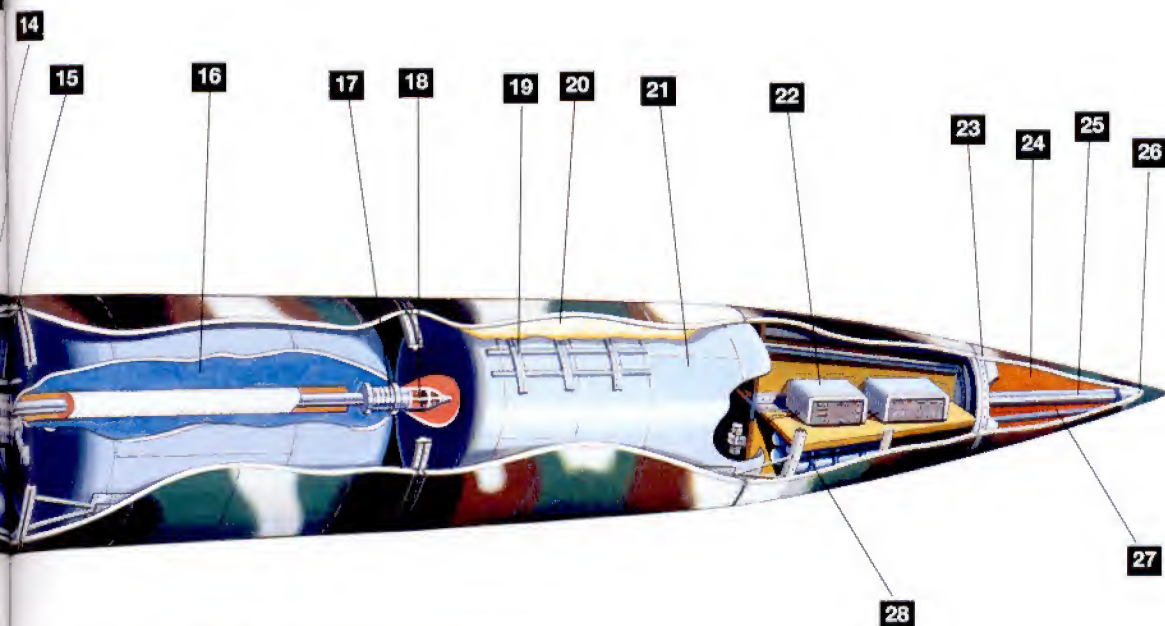
Engine: Liquid-fuel rocket using turbopump for fuel injection; 12-19 seconds warm-up thrust, 55 seconds at full power of 34-ton thrust

Maximum range: 314km

Apogee: 93.3km

Speed: 171m/s at engine cut-off; 132m/s at apogee; 184m/s at re-entry; 129m/s at impact; 330 seconds flight time





KEY

- | | |
|--------------------------------------|--|
| 1 Alcohol fuel injector | 16 Liquid oxygen (LOX) tank |
| 2 Graphite steering vane | 17 Bellows for alcohol feed duct |
| 3 Thrust ring | 18 Feed for alcohol duct to turbo-pump |
| 4 Rudder | 19 Fuselage reinforcement |
| 5 Rudder actuator | 20 Fiberglass insulation |
| 6 Stabilizing fin | 21 Alcohol fuel tank |
| 7 Rudder servo motor | 22 Guidance compartment |
| 8 Alcohol feed line | 23 Warhead base fuze |
| 9 Main combustion chamber | 24 Amatol high explosive |
| 10 Oxygen injector port | 25 Exploder tube |
| 11 Alcohol feed pipes | 26 Impact fuze |
| 12 Power-plant frame | 27 Alcohol pressurizing line |
| 13 Turbo-pump | 28 Nitrogen bottles |
| 14 Pressurized air bottles | 29 T-stoff (hydrogen peroxide) bottle for turbo-pump |
| 15 Bellows for alcohol and LOX ducts | 30 Aerial support fairing |

E1: A-4B Flame camouflage scheme



E2: A-4C Jagged camouflage scheme



F: A-4 mobile launch site



G: Feuerleitpanzer fire control vehicle



RAF was aware from the Dutch resistance that LOX was being supplied to the missile batteries by eight Dutch plants, only one was attacked since the other plants were in mostly residential areas. It was very difficult to target the launchers since they were usually camouflaged in wooded areas, and only a few missile crews were injured at the launch sites by fighter strikes. There were more than 10,000 fighter sorties flown against rail and road networks in The Hague and Hook of Holland areas to disrupt missile supplies. This was occasionally successful, as in late November when two trains were caught and all 40 missiles destroyed. The use of the Duindigt racetrack area eventually became so intolerable that it was heavily bombed in early March 1945, finally forcing the German missile batteries to abandon the area.

Of the 1,359 A-4 missiles launched against London, 1,039 were launched from The Hague and its suburbs while the rest were mainly launched from the Hook of Holland area. Of these, 169 (12 percent) were failures shortly after launch, 136 (10 percent) disintegrated in the terminal phase of the flight, 1,054 actually reached England, and only 517 hit the city and its suburbs, only 38 percent of the V-2 missiles launched. Civilian casualties in Britain from A-4 attacks totaled 2,754 dead and 6,523 wounded.

Although London was the best known target of the V-2 attacks, Antwerp in fact sustained more attacks, totaling some 1,610 launches. Of these, only 1,262 actually fell into the Antwerp area (78 percent) and only 598 into the city itself (37 percent). The intended target was the harbor, but only 152 of the missiles actually fell into this area. The heaviest casualties for any A-4 attack occurred on 16 December 1944 when an A-4 struck a cinema in Antwerp, killing 561 and wounding 291 more. The launch area for most of the attacks was in the Eifel area of Germany and Belgium, although some missiles were launched against Antwerp from the Dutch sites. As in the area around The Hague, misfires were a frequent concern for local German civilians, and the V-weapons were soon dubbed the "*Eifelschreck*" (Horror of the Eifel).

V-2 TARGETS

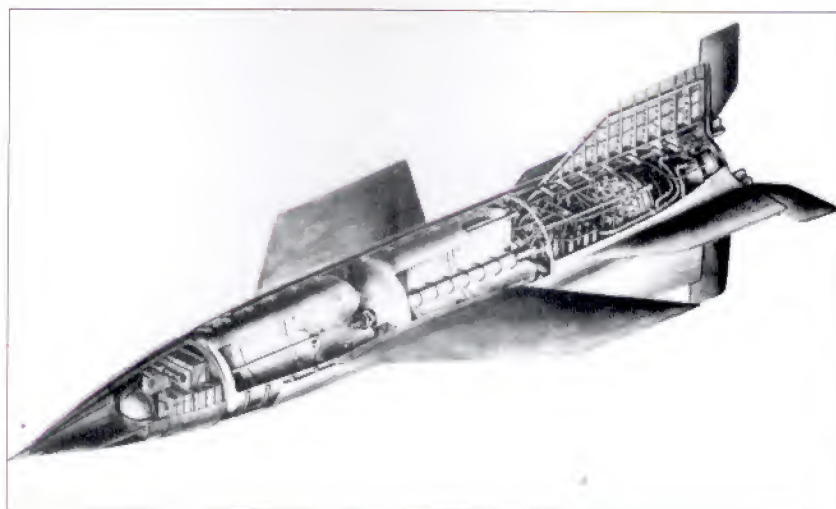
Country	City	Missiles
Belgium	Antwerp	1,610
	Luttich	27
	Hasselt	13
	Tournai	9
	Mons	3
	Diest	2
	Lille	25
France	Paris	22
	Tourcoing	19
	Arras	6
	Cambrai	4
England	London	1,358
	Norwich & Ipswich	44
Netherlands	Maastricht	19
Germany	Remagen	11
Total		3,172

One of the few times that the A-4 was used against a military target occurred on 11 March 1945 when 11 missiles were fired against the

Ludendorff bridge over the Rhine near Remagen, which had been recently captured by the US Army. Hitler ordered the missile attack at Himmler's instigation. SS Abteilung 500 was given the assignment since it was the only launch unit with the radio beacon guidance enhancement. Only one missile came within a mile of the bridge, and the average miss distance was 1.7km (11/10) miles in range and 3.5km (22/5 miles) in

azimuth according to the US Army reports. While such a level of accuracy is quite poor by modern standards, it was remarkably good compared to other V-2 launches in World War II.

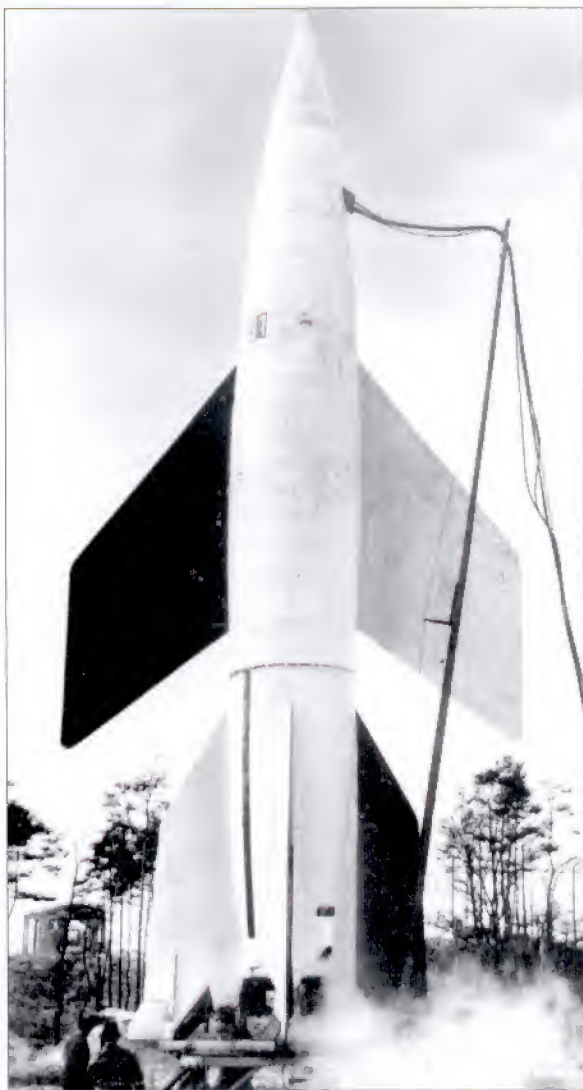
The British Rhine offensive in March 1945 finally put an end to A-4 launches from the Netherlands. The last six missiles were launched from The Hague against London on 27 March by Abteilung 485, Artillerie-Regiment 902, and the last against Antwerp the same day by SS Abteilung 500 from Hellendoorn. Two missiles were launched on 28 March by 3./Art. Rgt. 902 before it withdrew from Fallingbomel, but their target is unrecorded. Parts of Art. Rgt. 901 were ordered to re-form north of Hanover for the "Blücher Mission", a missile strike against Red Army forces around the encircled "fortress" at Kustrin (now Kostrzyn). Because of the turmoil in Germany at the time this never occurred, and on 7 April 1945 the surviving units destroyed their equipment rather than permit its capture. Most of the remaining missile units were ordered by Kammler to reorganize as infantry units. The only exception was Batterie 444, the original training unit, which was sent to Welmbüttel in Schleswig Holstein to carry out about five test missile launches into the North Sea. These were the last known missile launches of the war, and the battalion subsequently withdrew to the Hanover area where it destroyed its equipment. Kammler was later named to head the defense of Prague and his fate is still a mystery. He apparently had an aide shoot him rather than be captured. The Nordhausen production plant was captured by the US Army on 10 April 1945, though V-2 production had petered out in March 1945.



The A-9 was a 1942 scheme to extend the range of the A-4 by adding wings. This is the original conception with enlarged tail fins. (MHI)

FINAL MISSILE DESIGNS

With the final adjustments to A-4 missile design completed in September 1944, von Braun and the missile development team at Peenemünde were permitted to begin work on more futuristic derivatives. Hitler was particularly insistent on developing designs with more range, since the advance of the Allied armies was putting London out of reach. The first effort to develop a long-range version of the A-4, the A-9 *Flossen-*



When revived in 1944 as the A-4b, von Braun proposed a hasty "bastard" version of the A-9 using an A-4 fin section with modestly enlarged control fins. This is the A-4bV1 pilot, which crashed shortly after launch on 27 December 1944. (NARA)

geschoss (Winged Missile), had been cancelled in October 1942 to concentrate on the basic A-4. The A-9 scheme was revived in mid-June 1944, along with an associated test-bed design based on the smaller A-5 missile called the A-7. The aim of the revived A-9 program was to extend the range of the A-4 missile to about 800km (500 miles). It was renamed as the A-4b to take advantage of the high priority granted to the A-4 program by the industrial ministries. The first concern was roll control, which had been upset by the addition of the large wings. To speed the design along, von Braun suggested a "bastard" A-4b design that would use the existing A-4 tail controls with enlarged ailerons. No serious effort was made to develop control for the missile in the glide phase. The A-4b program was a hasty improvisation, done to placate Kammler and Hitler, with little prospects for immediate success. The first pilot, launched on 27 December 1944, began to roll almost immediately after launch and crashed within seconds. The guidance system simply could not handle the effects of the wings. Some improvements were made and a second test was conducted in late January 1945. This missile was much more successful, remaining in controlled flight until the re-entry when one wing ripped off. With the advance of the Red Army along the Baltic after the start of the Oder offensive, Peenemünde had to be abandoned a few days after the second launch, ending the A-4b program.

There were a number of even more futuristic designs such as the A-10. This began in 1936 as an enlarged A-4 with a 100-ton thrust engine and a 4-ton payload with a 500km (310 mile) range. It remained in limbo for many years but in 1941 was reconsidered as a multi-stage missile using the A-9 as its upper stage to make it possible to reach targets in the United States. The A-9/A-10 design was never more than a paper project, and the staging configuration was primitive and unworkable.

Another method to attack the United States would be to launch an A-4 from near the American coast. Since a launch from a surface vessel was implausible, a submarine launch was considered under the codename Test Stand XII. This program began in November 1944 and the initial concept was to construct a submersible launch canister, resembling an enormous torpedo, that could be towed behind a U-boat. The canister would contain a single A-4 missile, a small crew compartment and the necessary fuel tanks and buoyancy cells. Once near the American shore, the buoyancy tanks would be used to reorient the canister to a vertical launch position. The top of the canister would break the surface, the former bow would open, and the missile be prepared for launch. The Vulkan Docks in Stettin (now Szczecin) were given a contract

to build a test-bed that was supposed to be finished in April/May 1945. However, the project never received enough engineering support to progress beyond primitive conceptual designs, and Stettin fell to the Red Army on 26 April 1945 before any serious work began.

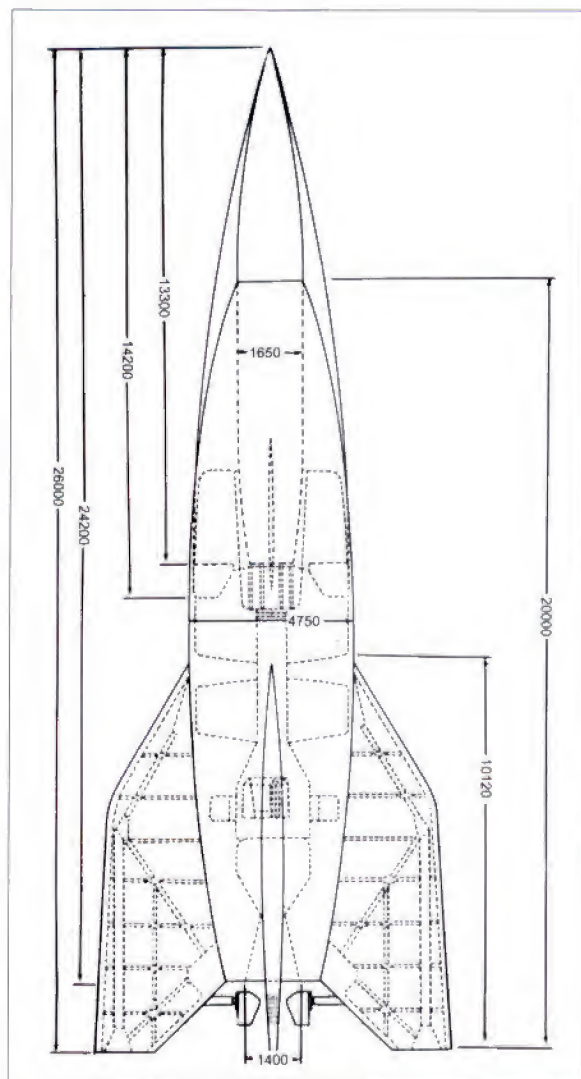
There were a number of programs to improve the A-4 and in the fall of 1944 a rail-mobile launcher program began, codenamed FMS (*Fahrbarbare Meteorologische Station: Mobile Weather Station*). This was an attempt to make the A-4 missile battery more compact and easier to move. Two trains were assembled for tests in 1945, but never became operational.

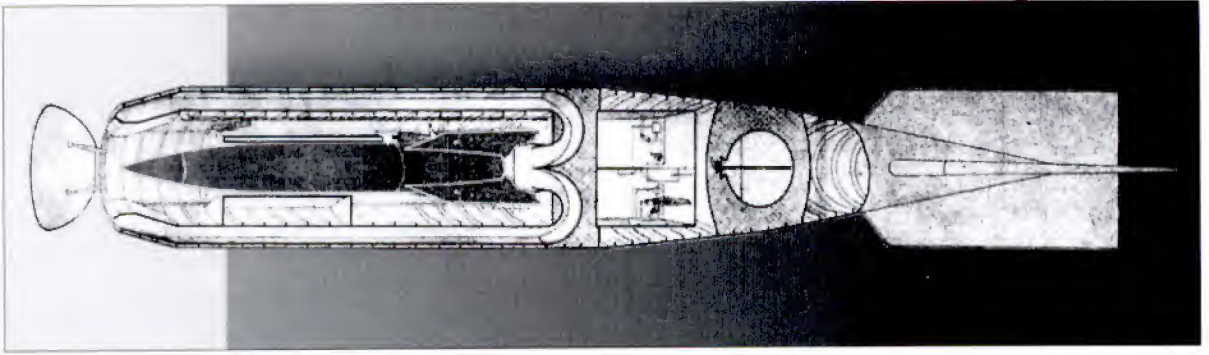
THE V-2 IN RETROSPECT

The V-2 missile program was a technical marvel from an engineering standpoint, but a spectacular flop as a weapon. The cost of the development and manufacture of the V-2 was staggering, estimated by a post-war US study as about \$2 billion, or about the same amount as was spent on the Allied atomic bomb program. Yet the entire seven-month V-2 missile campaign delivered less high explosive on all the targeted cities than a single large RAF raid on Germany. While such a massive expenditure might have been justified if it had had a military impact, the V-2 accomplished nothing of significant military value. Perversely enough, the civilian death toll in London, Antwerp, and the other cities was exceeded several-fold by the losses of the slave labor force involved in the missiles' manufacture at Nordhausen, to say nothing of the Dutch and German casualties from crashing missiles.

The decision to proceed with the mass production of the V-2 was premature on a variety of technical and tactical grounds. By committing to the use of a cryogenic fuel system based around liquid oxygen, the tactical deployment of the missile was considerably hamstrung. Even if all European liquid oxygen production in the summer of 1944 had been available to the V-2 force, this would have restricted the launch rate to only 30 missiles per day. Given the evaporation rate of liquid oxygen, and the loss of plants in France in August 1944, the actual launch capability declined to about two dozen launches per day when Operation Penguin began in September. The average launch rate of V-2 missiles during Operation Penguin was 16 per day, of which less than half hit within 16km (10 miles) of their intended target. In view of the rate of missile break-up and the missile's poor accuracy, at most Operation Penguin could have delivered about a dozen tons of explosives on London and Antwerp on a daily basis. While this could cause consid-

When the A-10 long-range missile project was revived in 1944, it was reconfigured as a multi-stage design with an A-9 missile as the second stage. It was a half-baked design that never proceeded beyond the drafting board. (NARA)





Test Stand XII was a conceptual design for a submersible missile container that could be towed by a U-boat and then reoriented to launch the missile from near the surface. Although a contract was awarded for the construction of a test-bed in Stettin, the port was captured by the Red Army in April 1945 before any significant work took place. (MHI)

erable misery to the civilians in these cities, it could hardly compare to the scale or accuracy of Allied bombing raids against Germany. The alternative to the use of cryogenic oxidants for rocket propulsion was the use of hypergolic fuels that could be stored at ambient temperatures, such as a nitric acid/kerosene combination. Such an alternative was studied as the A-8 until mid-1942 when it was cancelled for engineering and political reasons. Such a propulsion system was used on the Wasserfall anti-aircraft missile developed at Peenemünde but it was at a less advanced stage than the cryogenic fuel rocket engines. The V-2 was also hampered by its extremely poor accuracy, a consequence of the limitations of electronics technology at this time. This limited its use to terror bombing of Allied cities since it was not accurate enough to attack industrial or military targets with any hope of success.

Even for random terror bombing of cities, the V-2 compared very unfavorably to its stable-mate, the V-1 cruise missile. The crude little V-1 was much cheaper, costing only about a tenth as much to develop and manufacture as the V-2. The V-1 was fueled by readily available propellants and, since it was jet propelled, it needed no oxidizer. As a result 24,200 V-1s were launched compared to only about 3,500 V-2s, with an average daily launch rate of 110 V-1 to only 16 V-2 missiles. Dornberger had considered the V-2 a superior alternative to the V-1 since the launch sites were fixed and vulnerable, and the Buzz Bomb could be intercepted before reaching its target. Paradoxically, the vulnerability of the V-1 enhanced its military value since it compelled the RAF to make every effort to destroy its launch sites and shoot down every missile possible. From December 1943 to D-Day, the Allied air forces dropped 36,200 tons of bombs and lost 771 airmen and 154 aircraft attacking the V-1 sites. During the summer months after the Normandy invasion the Allied air forces expended one quarter of all their combat sorties and one fifth of their bomb tonnage on the V-1 sites. A significant fighter force was kept in Britain to protect against the V-1 and numerous anti-aircraft guns were used to defend London, Antwerp, and Liège. In contrast, the V-2, because it could not be intercepted, attracted far less defensive effort by the Allies. The mobility of its launch system greatly reduced the vulnerability of the launch crews and made Allied air attacks difficult if not impossible, so the Allied air forces sent far fewer missions against V-2 sites.

In terms of actual damage, the V-1 was a more effective weapon than the V-2 according to post-war studies by British and US military analysts. Since the V-1 warhead was not subject to the heat problems of

high-speed re-entry, its blast effect was far more destructive than the V-2 warhead because it could use a more powerful explosive. In addition, the V-2 warhead tended to detonate after it had penetrated the ground under buildings, which muffled its blast. In contrast, the V-1 tended to explode higher up in the building due to its slower descent speed, and the blast effect tended to be broader. Finally, the V-1 had a far greater psychological effect on civilians since its eerie sound could be heard over a very wide area, contributing to an unofficial mass evacuation of London in the summer of 1944. In contrast, the V-2 arrived unannounced, and the sound of its blast was localized. The decision to proceed to A-4 production in 1942 was taken before ballistic missile technology was ripe.

All in all the V-2 program was not too little too late as is so often claimed, but too much too soon.

THE V-2'S POST-WAR LEGACY

In the concluding months of the war, there was a race by Britain, the United States, and the Soviet Union to collect examples of Germany's most advanced military technology. There was special interest in the V-2 missile, since its propulsion and guidance systems were so far beyond anything developed elsewhere.

The United States scooped up most of the prizes. Kammler had evacuated most of the missile engineers from Peenemünde to Bavaria, and the rocket team, including Dornberger and von Braun, surrendered to US troops there in early May 1945. Most of the key engineering studies had accompanied the Peenemünde engineers, and these were recovered by US teams. The US Army also wanted to acquire intact V-2 missiles, and captured the Mittelwerk production facility on 10 April 1945. Unfortunately, this was in an area scheduled to become part of the Soviet occupation zone. As a result, an ordnance team under Colonel H. Toftoy started to evacuate as much as possible with a deadline of 1 June 1945 when the Red Army was scheduled to take possession of the area. Some 400 tons of equipment, including components for about 100 missiles, were transported by rail to Antwerp during 22–31 May 1945. Although the Russians were unaware of the operation, British officers were aggravated by the shipments due to previous agreements on sharing of captured technology, and they attempted to stop the dispatch of the missiles back to the United States. These protests were ignored, but in 1946 a number of V-2s were given back to Britain to conduct tests. Key German engineers were offered the opportunity of resettling in the United States to assist in a post-war US missile program under the codename "Overcast" (later "Paperclip") and the first

In the final month of the war, there was a race to scoop up the crown jewels of German technology. The US Army seized the Nordhausen production facility, and rows of incomplete A-4 missiles can be seen in the nearby storage area. (NARA)





The US Army launched over 60 captured A-4C missiles from the White Sands proving ground after the war. This is the second American V-2, launched on 16 April 1946. (NARA)

of an eventual total of 127 arrived in late September 1945.

The US Army began to conduct test launches of the captured V-2s from the White Sands proving ground in the deserts of New Mexico as part of the Hermes ballistic missile program. The first V-2 was launched on 16 April 1946. A total of 63 of the 67 V-2 missiles assembled in the US were launched through 1952, many of them with scientific payloads to explore the upper atmosphere. On 24 February 1949 a modified V-2 with an additional stage called the Bumper-WAC was launched to an altitude of 400km (250 miles), paving the way for multistage ballistic missiles. The US Army never seriously considered restarting manufacture of the V-2 missile in the United States as its accuracy and logistics problems were quickly appreciated. Instead, a new tactical ballistic missile, the Redstone, entered development at Redstone Arsenal in 1951 by a team of US and German engineers. It was a single-stage design using LOX/kerosene fuel which gave it an effective range of 320km (200 miles) and an accuracy of 294m (980ft). Its guidance system was a substantial advance over the V-2 system, but its 4-megaton nuclear warhead was the innovation that made missiles like this such a fearsome and revolutionary new weapon in the 1950s.

The US Air Force monitored the V-2 program, and began a spin-off design at Convair in 1946 called the MX-774. Although resembling the V-2, the MX-774 was significantly smaller due to the use of a monocoque fuselage, with the outer fuselage skin also forming the fuel tanks. It incorporated many key innovations including a gimbaled engine for steering and a separable warhead to get around the V-2's disintegration problems. Although a significant advance over the V-2, the Air Force wanted much greater range and settled on the cruise missile option instead, taking this forward in the Navaho and Snark programs.

The US Navy launched a single V-2 from the deck of the carrier USS *Midway* on 6 September 1947. The Navy was very skeptical of the use of dangerous liquid fuels on ships, and a study called Operation Pushover in 1949 convinced the Navy that the risk of accidents was too great. The Navy showed no serious interest in ballistic missiles until solid-fuel propulsion proved practical, and only began its Polaris program in late 1956.

While the absorption of German missile expertise gave the United States a first step into missile technology in the late 1940s, it had less effect on military programs than on later space programs. Von Braun's team was assigned to the Army's missile effort, and the Army was pushed out of long-range ballistic missile development in the mid-1950s in favor of the Air Force. However, the Army's Redstone Arsenal in Huntsville,

Alabama, formed the seed of the American space program, and von Braun and the Peenemünde engineers made significant contributions to the program of manned spaceflight, including the lunar program.

Britain led the effort to conduct early flight tests of the V-2 using captured German missile troops in Operation Backfire. An experimental site was formed at the old Krupp naval gun range at Altenwalde, with General Dornberger leading German missile crews who conducted the test launches. The first was made in October 1945, using some of the missiles originally spirited away from Nordhausen by the US Army. The V-2 launches had little impact on British technological development as, in 1948, the Ministry of Supply curtailed any further work on long-range missiles because of the country's post-war austerity program. The British missile effort was not revived until 1955 as the Blue Streak program, by which time missile technology had leapt forward from the V-2 by a generation. France recovered a single V-2 missile from Peenemünde in 1945 and, while it served to inspire French interest, it had few practical consequences.

RED V-2

The only country to continue the manufacture of the V-2 missile after the war was the Soviet Union. A dedicated missile exploitation team was not established until the summer of 1945 and, when it arrived in August 1945, the US Army had already thoroughly pillaged the Nordhausen plant. The aim of the Soviet program was to collect as much German missile technology as possible, to reconstruct production facilities in Germany, and to use this experience to create a similar plant back in the Soviet Union. Although the US Army had secured the services of most of the senior German missile engineers from Peenemünde, Helmut Grottrup, the head of the V-2 guidance team, decided to join the Soviet effort and a number of other engineers were rounded up. The Soviets established Institut Rabe in occupied Germany, which included the production facility at Nordhausen and what was left in the rubble at Peenemünde. Institut Rabe managed to assemble 30 V-2 missiles by September 1946 and to rebuild the two FMS mobile launch trains. These were dispatched to the new Soviet missile proving ground at Kapustin Yar east of Stalingrad (Volgograd).

With the task of preparing experimental V-2 missiles in Germany complete, in October 1946 the German engineers were forcibly transferred to Gorodomlya Island near Moscow. They were isolated from their Soviet counterparts, although senior Soviet missile engineers such as Sergei Korolev met with them frequently to consult on future missile designs. In April 1947 Stalin authorized the local production of V-2 copies, called the R-1 (*Raketa-1*), once tests of V-2 missiles assembled from German components were completed. The first A-4 was launched successfully on 18 October 1947 and this was followed by some 20 additional launches through December 1947. Following the tests, Korolev's missile team was mainly involved in establishing an indigenous Soviet production line for the R-1A in the Moscow area.

Small-scale production of the R-1A ballistic missile began in 1948. The first test launch of a Soviet-manufactured R-1A on 17 September



Many of the later American V-2 launches were used for scientific studies of the upper atmosphere, such as No. 12, on 10 October 1946, which contained a scientific package to measure ozone. (NARA)

1948 failed, and the first successful test followed on 10 October 1948. Testing continued through 1950 and the R-1 missile system was accepted for use by the Soviet Army on 28 November 1950. Series production of the R-1 missile was far from assured. The influential artillery head, Marshal N.D. Yakovlev, argued that the new ballistic missiles were inordinately expensive, too cumbersome to use, and not militarily effective. One general remarked that if his troops were given as much alcohol as was used to fuel a single R-1 missile, they could capture any town! Stalin and the party leadership authorized production anyway, recognizing that it was only a first step in a more ambitious scheme to field long-range missile weapons. The Dnepropetrovsk Automobile Factory, which had been created in Ukraine after the war based on machine tools taken from Germany, was converted to a missile plant and it would eventually become the world's largest.

R-1 and R-2 missile production

1951	1952	1953	1954	1955	Total
76	237	544	308	380	1,545

Production of the R-1 was quickly followed by the R-2, an evolutionary improvement intended to increase its range. Like the American MX-774, the R-2 used a monocoque fuselage and engine improvements which increased range from 300km to 600km (186–373 miles). The flight testing of the R-2 began in September 1949; it was accepted for service on 27 November 1951, and the first series production missile was completed in June 1953.

When the R-1 missiles became available in the fall of 1950 Soviet missile units began to be organized at Kapustin Yar. The first was given the cover name of 23rd Special Purpose Engineer Brigade of the Supreme High Command Reserve (23 BON-RVVK). Through March 1953 six missile brigades were formed. The R-1 and R-2 missiles were limited to high explosive warheads since the low reliability of the missiles, the heavy weight of early Soviet nuclear devices, and the relatively small number of nuclear warheads available until 1954 dis-

couraged a nuclear-armed version. As a result, there was some interest amongst missile advocates in alternative types of warheads that could improve their combat effectiveness. The idea arose to use warheads filled with nuclear reactor waste. Such a warhead would contaminate larger areas than would be damaged by conventional high explosive warheads.

In the early 1950s two warheads filled with "military radioactive agents" were developed

The Soviet Union conducted its tests of captured German A-4 missiles from a new proving ground near Stalingrad at Kapustin Yar. Here, a tractor tows a standard German liquid oxygen trailer and pumping semi-trailer to the launch site. (A. Aksenov)





The Soviet Union began manufacturing a copy of the A-4C missile in 1950 as the R-1A. The *Meillerwagen* was also locally copied though much of the support equipment was based on local vehicle types. (A. Aksenov)

for use with the R-2 missile. The *Geran* (Geranium) warhead was filled with radioactive liquid and fuzed in such a way that, at a pre-selected altitude, the warhead would burst open and the liquid spray out as radioactive rain. The *Generator* warhead had the radioactive liquid in a large number of small containers which would splash open on impact with the earth. The test launches of the *Geran* and *Generator* missiles lasted from 1953 to 1956 but there is little in the available records to determine whether they were deployed. After series production of nuclear warheads began in 1954 a nuclear fission warhead was developed for the R-2, and test flights of a modified R-2 were conducted in November 1955. The warhead was accepted for service in 1956 but, by the time it became available, more modern missiles were entering service and there is little evidence that nuclear-armed R-1 or R-2 missiles were ever fielded.

The R-1 and R-2 were replaced in tactical missile units by the R-11 (Scud A) starting in 1958. The idea that the Scud was derived from V-2 missile technology is a myth. The Scud was a repudiation of the legacy of the V-2, opting for the hypergolic fuel configuration of the German Wasserfall missile, which was a more practical solution for field operations than the use of cumbersome liquid oxygen.

Curiously enough, the V-2 also served to form the basis of the Chinese missile program. In 1956 the Soviet Union agreed to provide China with missile technology, and began transferring a small number of R-2 missiles and technical documents. Declining political relations between the two erstwhile allies delayed the program, and limited production of the Chinese copy of the R-2, the DF-1, did not begin until the fall of 1960. In November and December 1960 China conducted its first tests of the DF-1. Series production was on a very small scale as even the Chinese appreciated that it was an obsolete design. The Chinese DF-1 was the last ballistic missile design directly linked to the V-2.

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The legacy of the V-2 stretched far afield. In 1960 China began testing its first ballistic missile, the DF-1, which was a copy of the Soviet R-2 missile. It was not manufactured in significant numbers as this technology was clearly obsolete by the early 1960s. (T. Desautels)

COLOR PLATE COMMENTARY

A: EARLY GERMAN TEST ROCKETS

A1: A-3 experimental rocket

A2: A-5 experimental rocket

A3: A-4V4 prototype ballistic missile

The A-3 was initially finished in bare metal, but was later painted in an overall dark gray scheme for trials. The A-5 rockets were finished in a variety of schemes, this early yellow and red scheme being one of the more colorful. This quickly gave way to more practical test-schemes of white and black (RAL 9010 clear white, RAL 9011 graphite black), usually dividing the missile in halves or quarters. These schemes were adopted to help monitor the rate of roll of the missile using camera trackers as roll problems were common in the early missiles. This type of scheme is seen here on A-4V4, the fourth A-4 missile and the first to be launched on a completely successful flight on 3 October 1942. Many of the early A-4 test missiles had whimsical cartoons painted on them, sometimes with a science fiction flavor as in this case, the "Woman on the Moon" inspired by the 1929 Fritz Lang film *Frau im Mond*.

B: WIZERNES MISSILE BUNKER

This illustration shows how the Wizernes missile base might have looked had it been completed. In the foreground are the tunnels associated with the railroad line that supplied the base. The main chamber was carved out of a limestone

quarry with two tunnels, *Gretchen* and *Gustav*, leading from the preparation chamber to the quarry pit where the missiles would be launched. In the background is the "Worms' Gallery", the extensive series of tunnels planned for storing the missiles and supplies.

C: COLOR SCHEMES

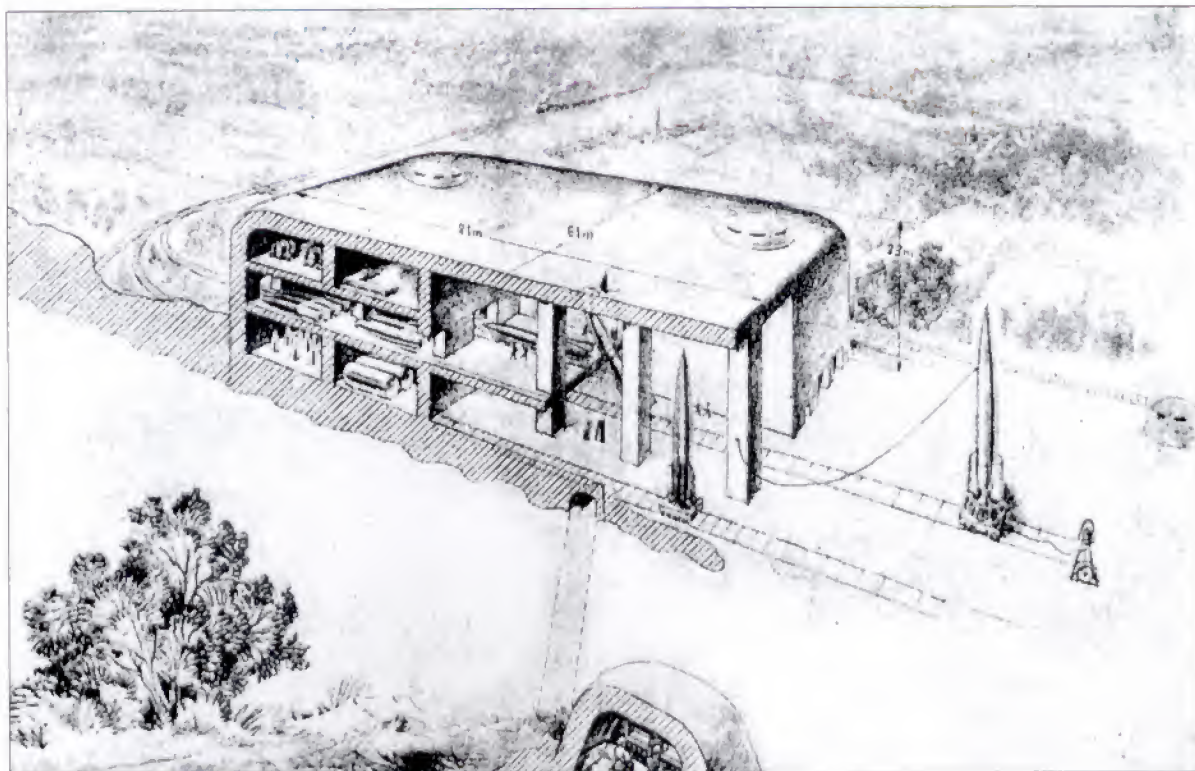
C1: A-4, Peenemünde late test scheme

The later A-4 test missiles in 1943 were often finished in a scheme closer to the tactical schemes with most of the fuselage painted in RAL 6003 olive green. However, the tail and engine section remained in various patterns of black and white for tracking purposes. There was often a gray stripe left running down the center.

C2: A-4B Batik camouflage scheme

In June 1943 a test of three camouflage schemes began to determine which would be the most effective for concealment. The most elaborate of these was the *Gebatikt* scheme (*batik*: a type of Indonesian fabric dyeing) of spray painted irregular patches in five colors: RAL 9001 cream white, RAL 7028 earth gray, RAL 3039 red oxide, RAL 6003

This architectural sketch shows the original scheme for the Watten missile bunker. Missiles were to be prepared within the bunker, and then wheeled out for launch. (NARA)





Peenemünde was subjected to a series of air attacks starting on 18 August 1943. The aerial reconnaissance photo at the top shows Test Stand VII in June 1944 with three A-4 missiles and a single empty *Meillerwagen* towards the bottom of the photo. The reconnaissance photo below it shows the test stand in September 1944 after it had been bombed. (NARA)

olive green and RAL 8017 chocolate brown. This scheme was quickly dropped due to its complexity.

D: CROSS-SECTIONAL DRAWING OF V-2

See plate for full details.

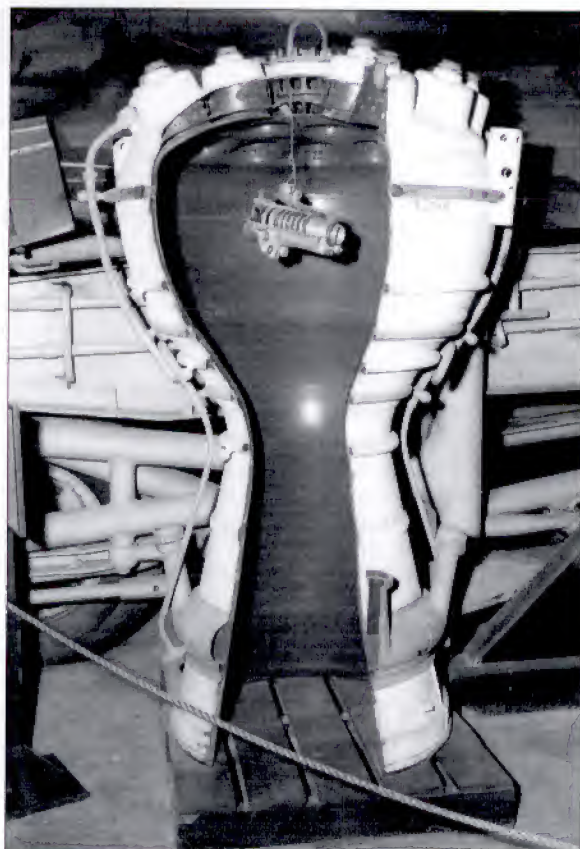
E: CAMOUFLAGE SCHEMES

E1: A-4B Flame camouflage scheme

The second of the three June 1943 test schemes was the *Geflammt* (flame) scheme, which was a simplified version of the *Gebatikt* scheme, with only three colors (RAL 9001 cream white, RAL 7028 earth gray and RAL 6003 olive green), applied in a wavy, hard-edged pattern but retaining the broad white bands seen in the earlier scheme. This was the least common of the three test schemes.

E2: A-4C Jagged camouflage scheme

The third June 1943 scheme, and also the most common,



This cutaway shows the characteristic shape of the main exhaust chamber of the A-4 engine. The fuel was injected into the chamber from the ports in the top, with one of the injectors dangling inside the chamber. The piping around the chamber cooled the chamber wall with alcohol. (USAOM, APG)

was the *Gezackt* (ragged) pattern consisting of the same three colors (RAL 9001 cream white, RAL 7028 earth gray and RAL 6003 olive green) as the *Geflammt* scheme, but in large, jagged patterns. This was the only scheme actually adopted for tactical use, but by the time that production had started at Nordhausen in 1944, it was simplified somewhat and RAL 9003 signal white used in place of cream white. Due to the added expense and effort required to camouflage the missiles, the camouflage painting quickly ended in 1944 in favor of an overall finish of RAL 6003 olive green. The markings were limited to a thin yellow band on the nose to indicate an explosive warhead. The missile serial number was painted in mid-fuselage on two sides, and in smaller characters between the fins on the opposite sides.

F: A-4 MOBILE LAUNCH SITE

This shows the configuration of the mobile launch site during the fueling process. The A-4C is resting on the base-plate and the *Meillerwagen* has been withdrawn several feet to

permit the servicing platforms to be folded down for work on the control section. The vehicle centered behind the missile is the hydrogen peroxide tanker, which provides oxidant to the engine's turbopump. To its left is the alcohol tanker. Behind the alcohol tanker is a pump trailer used in the fueling process. The tandem team behind these is composed of an SS-100 tractor towing an alcohol trailer. On the right side of the *Meillerwagen* is another tractor, but towing the main oxygen trailer.

G: FEUERLEITPANZER FIRE CONTROL VEHICLE

The fire control vehicle for the A-4 launch section was based on the SdKfz 7 half-track with an armored shelter mounted on the rear. It was finished in the usual scheme of RAL 7028 dark yellow. On the rear fender is the tactical insignia of the Division zbV in white. While the suggested practice was to place the vehicle in a revetment about 100–150m from the launch pad, often there was neither the time nor earth-moving equipment available for this. So the vehicle would sometimes be left in the open as seen here, but with some branches placed about it as camouflage against the roving RAF fighters that frequented the launch sites around The Hague.

RIGHT After the A-4 missile was erected on to the launch pad using the *Meillerwagen*, the trailer was pulled back a short distance since the erector arms acted as a gantry during missile preparation. The cylindrical tank on the arm was used to fuel the engine turbopump. (NARA)

BELOW For R-1A fire control vehicles, Soviet missile brigades used modified SU-85 assault guns with their armament removed and replaced with the appropriate electronics. (A. Aksenov)



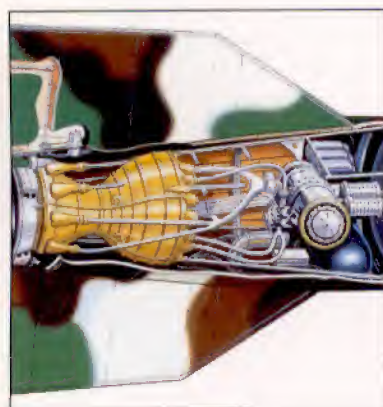
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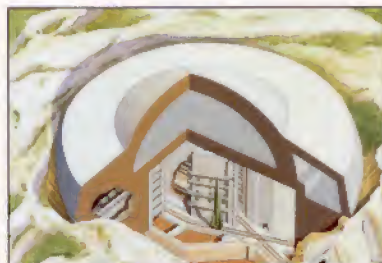
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